DECEMBER 2024 | VOLUME 04 | ISSUE 12

(ISBN : 978-81-965582-9-1)

AgriGate

GROW WITH EVERY PAGE!

An International Multidisciplinary Monthly e-Magazine

From the Desk of Editor-in-chief

December 2024| Vol. 04 | Issue 12

I would like to introduce the launch of **"AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 04 Issue No. 12 – December 2024"** with immense pleasure. Our team is privileged to dedicate this issue to the **Farmers.** **Farmer's Day in India or National Farmer's Day** is celebrated on 23 December across the country to commemorate the birth anniversary of the former Prime Minister Chaudhary Charan Singh. On this day various events, seminars, functions, and competitions are organized on agriculture and its importance to educate and provide knowledge to the people. **World Soil Day** is observed on 5 December to raise awareness about the importance of soil, healthy ecosystems, and human well-being.

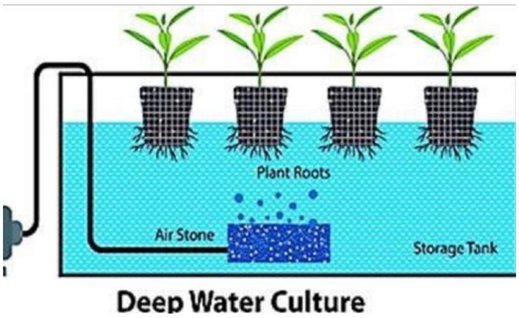
The main objective of the magazine is to provide a publishing platform to young researchers and scientists as well as an information hub for the enthusiast, progressive farmer and also common readers. We envisage providing an online platform that appreciates illuminating articles on various topics related to agriculture and allied sciences monthly that will appraise and update the students, farming community and the whole society at large on the updates in agriculture.

Last but not the least, I wholeheartedly thank the editorial team, authors as well as anonymous reviewers for contributing to the release of this issue.

Our team welcomes your constructive feedback and suggestions to improve delivering fruitful content to hungry minds.

Dr R Shiv Ramakrishnan
Editor-in-chief
AgriGate Magazine

CONTENTS



CONTENTS

Ragi Cookies

CONTENTS

CONTENTS

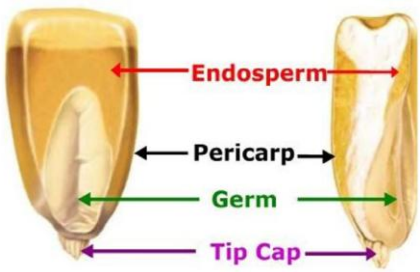
CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

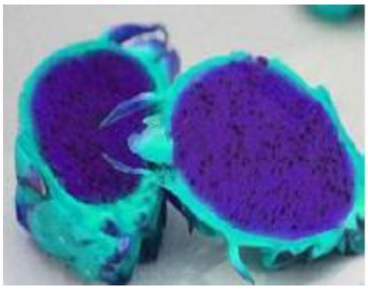


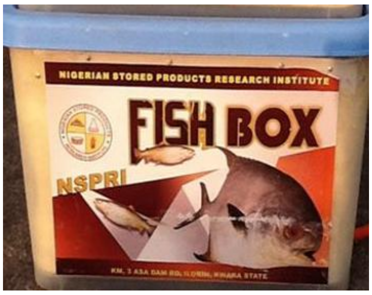
CONTENTS

CONTENTS

CONTENTS

CONTENTS




NIGERIAN STORED PRODUCTS RESEARCH INSTITUTE
FISH BOX
NSPRI

CONTENTS

CONTENTS

CONTENTS

AGRI INNOVA 2025

International Conference on Advanced Innovations and Technological Frontiers in Agricultural Sciences, Agricultural Engineering, Sericulture, Food Technology, Biotechnology, Fisheries Science, Veterinary and Animal Sciences 2025

Jointly Organized by

Western Ghat Researcher Association of Agricultural Sciences and Technology (Registered under Section 8 Organization, Ministry of Corporate Affairs, Govt. of India)

Department of Agricultural Engineering, RVS Technical Campus (Autonomous), Affiliated to Anna University Coimbatore, Tamil Nadu, India

Scan QR for Registration

Registration Extended to 30.12.2024

09th & 10th JANUARY 2025
VENUE: DEPARTMENT OF AGRICULTURAL ENGINEERING, RVS TECHNICAL CAMPUS (AUTONOMOUS), KUMARAN KOTTAM CAMPUS, KANNAMPALAYAM POST, SULUR, COIMBATORE, TAMIL NADU, INDIA.

In Coordination With

Academic Partner

RVS Agricultural College Affiliated to TNAU Thanjavur, Tamil Nadu

Technical Knowledge Partners

METVSO Research Foundation Madurai, Tamil Nadu

PROSPER Foundation Theni, Tamil Nad

Agri Amigos Pvt. Ltd., Theni, Tamil Nadu

Incubation Partner

Media Partner

Industry Knowledge Partners

CREA Foundation, Trichy, Tamil Nadu

Greenerg Mobility Solutions Pvt. Ltd., Coimbatore, Tamil Nadu

Department of Agricultural Engineering
RVS Technical Campus (Autonomous),
Affiliated to Anna University
Coimbatore, Tamil Nadu, India

Western Ghat Researcher Association of Agricultural Sciences and Technology
(Registered under Section 8 Organisation,
Ministry of Corporate Affairs, Govt. of India)

For Communication 9361885985 | 8610561280 | 9842642848 | 9944010268

Volume: 04 Issue No: 12

MODERN INNOVATIVE DIGITAL TECHNOLOGIES IN FISHERIES

Article ID: AG-VO4-I12-01

Soumya Priyadarshini, Santosh Kumar Udgata and Arpit Acharya *
College of Fisheries, OUAT, Rangailunda, Berhampur -07, Odisha, India
*Corresponding Author Email ID: acharya.arpit18@gmail.com

Introduction

Fisheries is an emerging livestock sector that significantly contributes to food, nutrition, employment, and income for millions of rural populations. The continued depletion of wild fish stocks is placing increased strain on the aquaculture sector, affecting its sustainability. Aquaculture is diverse, with a wide range of species. Many marine fish stocks are overexploited, and there is considerable overcapacity in fishing fleets worldwide. This imbalance between resource availability and fishing capacity is exacerbated by technological development, known as "technological creep." Significant pressures exist for the industry to innovate, aiming to enhance sustainability through increased fish production, improved species selection, disease resistance, reduced wastage, environmental pollution prevention, and global employment generation. This article examines how digital transformation can support the expansion needs of the fisheries and aquaculture industries, utilizing ICT, IoT, cloud-edge computing, AI, machine learning, immersive technologies, and blockchain.

Technologies such as echo sounders, net sondes, fish aggregating devices (FAD), and global positioning systems (GPS) are improving global food chain efficiencies, productivity, and reducing waste, contamination, and food fraud. Recently, the focus on digital technologies has evolved, integrating AI and robotics with human intelligence to advance human-centric solutions. Modern technologies help promote national food security, income, and livelihood generation, as well as research and development. However, their unregulated, irregular, illegal, and irresponsible use of fisheries gear can degrade and deplete natural aquatic resources through overexploitation and habitat and ecosystem degradation. This study emphasizes the need for regulated and responsible use of modern technologies to ensure sustainable practices in the fisheries and aquaculture sectors, ultimately fostering a balanced and productive global food chain.

Satellite Tags

With the advent of tiny microprocessors and advanced remote sensing systems, scientists can now study marine animals and the open ocean from a unique perspective using "smart tags." These tags allow researchers to gather valuable data on migratory routes, diving, resting, and swimming patterns, as well as internal physiological processes like digestion. These "smart tags" are especially useful in tracking:

- Highly migratory species like sharks, tuna, and albacore.
- Sea turtles.
- Sea lions and seals.
- Whales,

Drones (Aerial and Sail)

"Remote sensing" is the science of gathering information about Earth's land and oceans through distant imagery, such as satellite and aerial photography. Researchers leverage data collected by drones to study essential habitats and assess the distribution and abundance of species in regions that are challenging to access using traditional survey methods. These drones, equipped with six helicopter rotors for vertical takeoff and stable hovering, feature high-resolution digital cameras for precise data collection.

Underwater Vehicles

To study marine life, scientists utilize underwater vehicles, which include autonomous underwater vehicles (AUVs), manned submersibles, and remotely operated vehicles (ROVs). ROVs are tethered to a surface vessel, while AUVs operate independently. AUVs are directed by commands from an operator-controlled computer, dictating their sampling locations, times, and targets. They are also equipped with various tools for sampling and surveying, such as cameras, sonar, and depth sensors.

Robotics And Autonomous Systems

Several facets of fisheries management are transforming by dint of robotic technologies. Without the human interventions, underwater vehicles (UUVs) with sensors and cameras may scan marine ecosystems, monitor habitats, and evaluate fish stocks (Smith et al., 2010). With the ability to autonomously collect data on temperature, salinity, and water quality, autonomous underwater gliders can offer significant insights into the health of marine habitats. Additionally, aerial robotics and drones are employed for airborne surveys, allowing for quick evaluation of fish shoals, spotting unlawful activity, and supporting search and rescue efforts Robotics and Autonomous Systems.

Sensors to measure water parameters and monitor feeding and health status.

Sensors can be used in collecting water parameters, including dissolved oxygen (DO) levels, pH values, salinity, turbidity and pollutant concentration (Su et al., 2020; Xing et al., 2019). In fact, many of the above-mentioned robots and drones use sensors to obtain data in real time in water. In the aquaculture industry, biosensors have been developed and applied to analyse DO levels, water salinity and temperature (Antonucci & Costa, 2020; Su et al., 2020). In the salmon industry, the heart rate and metabolism of individuals can be monitored and recorded (Svendsen et al., 2020). Using underwater sensors connected to the internet, the hunger status of cultured fish in cages, ponds and rivers can be monitored, and thus feeding can be conducted accordingly (Zhou et al., 2019). Proper feeding according to the hunger status can substantially increase feed usage and reduce the wastage of feeds, thus reducing total production costs (Li et al., 2020; Su et al., 2020)

Internet of things connects different parts of the aquaculture industry

The internet of things (IoT) is playing an important role in many industries (Gubbi et al., 2013). IoT is relatively new in aquaculture (Jothiswaran et al., 2020). It is able to connect big data (i.e. massive amount of streaming data) across the entire aquaculture industry (Fig. 4). This technology brings new opportunities to the industry (Kamaruidzaman & Rahmat, 2020).

There are several benefits of applying the IoT technology in the aquaculture industry.

- The environmental conditions in aquaculture sites can be effectively monitored in real-time and with higher coverage by incorporating many underwater cameras and sensors across multiple cages.
- It allows for better environmental management by monitoring the effects of fish farms on the surrounding environment continuously and on time.
- IoT in combination with machine learning with data acquired over time can be applied to generate predictive models.

Augmented reality (AR) improves production efficiency and enhance aquaculture education

AR is an interactive experience in the environment of a real-world. The objects locating in the real world are strengthened with assistance of computer-generated perceptual information (Jung, 2019). In AR, objects produced by a computer are used to improve the impression of real-world experiences by adding clarity and data. Aquaculture activities are highly variable, unforeseeable, laborious and dependent upon the species, location and aquaculture systems (FAO, 2020). AR is able to decrease cost, spare time and facilitate underwater drone and robot operations, including monitoring fish behaviour, net holes and dead fish (Stene, 2019). With the assistance of AR, farmers may gain a better overview in production places, and complete operations more effectively and with zero risk. AR has been used in the aquaculture industry to increase the efficiency of field production, monitor and analyse mortalities, health status and measure many water parameters (Xi et al., 2019). Recently, an AR plus cloud system was designed to improve in-situ water quality data collection and query (Xi et al., 2019). However, affordability of this system is very critical issue in small aquaculture farm due to its huge expense.

Microcomputer-controlled demand feeder for the study of feeding behavior in fish

The electromechanical design ensures a single-pellet delivery for each demand. The feeder, activated by a fish pressing a bar, is driven by a solenoid. A variety of pellet shapes and sizes can be used, offering broad experimental versatility. The feeder is also suitable for microcomputer control.

Conclusion

These recent advancements in the fisheries sector have streamlined operations and increased efficiency. However, significant challenges remain, particularly the lack of knowledge among farmers at the grassroots level. Additionally, the high investment costs associated with these technologies are prohibitive for small-scale farmers. Therefore, it is crucial to develop cost-effective technological solutions that are versatile and accessible to all farmers, ensuring that these innovations can be widely adopted and benefit the entire industry.

References

Ab Rahman, A., Hamid, U. Z. A., & Chin, T. A. (2017). Emerging technologies with disruptive effects: A review. *Perintis eJournal*, *7*(2), 111-128.

Antonucci, F., & Costa, C. (2020). Precision aquaculture: a short review on engineering innovations. *Aquaculture International*, *28*(1), 41-57.

Burnell, G., & Allan, G. (Eds.). (2009). *New technologies in aquaculture: Improving production efficiency, quality and environmental management*. Elsevier.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

WINTER FLOWERS: A KALEIDOSCOPE OF COLORS AND ELEGANCE

Article ID: AG-VO4-I12-02

M.Vasantha Ratna[1*] and G.Sneha Leela[2]

[1]Research Scholar, Department of Floriculture and Landscape Architecture, Dr.Y.S.R Horticultural University, Venkataramannagudem, AP, India-534 101

[2]Research Scholar, Department of Vegetable Science, Tamil Nadu Agricultural University, Coimbatore, TN, India-641 003

*Corresponding Author Email ID: manukondaraju299@gmail.com

Abstract

Winter flowers bring a kaleidoscope of colors and elegance, transforming the cool season into a vibrant celebration of nature's beauty. This article explores the cultivation and aftercare of winter-season flowers, emphasizing their adaptability to cooler climates and their aesthetic, medicinal, and ecological benefits. From the radiant marigolds and cheerful zinnias to the timeless elegance of carnations and the grandeur of larkspurs, winter blooms thrive in optimal conditions of sunlight, well-drained soil, and moderate watering. These flowers not only enhance garden landscapes but also offer practical uses such as dye production, medicinal properties, and even culinary applications.

Keywords: Winter flowers, ornamental gardening, marigold, snapdragon, chrysanthemum, medicinal, aesthetic appeal

Introduction

Flowers have long been cherished as timeless gifts to express the deepest emotions and convey love, joy, or solace. Winter brings a unique opportunity to nurture vibrant flowers that thrive in the cooler months, offering beauty and tranquillity. From marigolds to larkspurs, these winter blooms brighten gardens, homes, and hearts alike. Any landscape design must include winter-flowering annuals (Brown, 2012). According to Love et al. (2009), they are commonly used as window baskets, bedding plants, garden plants, rockery plants, loose flowers, cut flowers, and herbaceous border in gardens. Let's delve into the essential aspects of growing winter flowers, along with detailed descriptions of some popular varieties.

How to Care for Winter-Season Flowers

- ✓ Select plants of appropriate size as growth slows during winter.
- ✓ Use containers proportional to the plant size to allow ample root space.
- ✓ Place plants where they can receive abundant sunlight, as many winter flowers thrive in bright conditions.
- ✓ Water sparingly during winter, ensuring that the soil doesn't become waterlogged.
- ✓ Feed plants regularly with liquid fertilizers to encourage healthy blooms.
- ✓ Ensure containers have proper drainage holes to avoid water stagnation.

Winter Gardening Essentials

- ✓ Begin sowing seeds as soon as winter sets in. Most flowering seeds need a soil depth of around 5 inches, so opt for pots that are 6-8 inches deep. Plant seeds about 2 inches below the surface.
- ✓ With proper care, saplings begin to emerge in approximately six weeks.
- ✓ Water plants thoroughly as required and place them in areas with adequate sunlight.

Popular Winter Flowers

1.Marigold (*Tagetes erecta*):

Winter is a season of tranquility, yet it offers the perfect backdrop for vibrant, colorful blooms. Among the most beloved winter flowers are **marigolds**, available in two popular varieties-French and African. While French marigolds are smaller with a mix of mahogany red and orange shades, African marigolds are larger and predominantly yellow to orange. Their green, lanceolate leaves are 5–17 cm long, and they can reach a height of 50–80 cm. Little hairs cover the leaves and stems, and the leaf margins may be wavy. It requires temperatures between 20°C and 30°C, and it produces a lot of flowers every year during the winter and rainy seasons (Kar and Patra 2022). Both thrive at 18–20°C and require at least 6–8 hours of sunlight. Known for their subtle citrusy fragrance, marigolds are easy to propagate by preserving seeds from dried flowers.

2. Calendula (*Calendula officinalis*):

The Asteraceae family member Calendula is commonly referred to as English marigold or pot marigold. For centuries, traditional medicine has utilized the fragrant herb marigold. In order to gain a better understanding of the various biological activities and modes of action of calendula species, they have been highlighted. This plant is rich in quinines, volatile oil, sterols and steroids, amino acids, flavonoids, glycosides, and carotenoids. In medicine, calendula oil is still used as an antitumor and wound-healing agent (Patil *et al.,* 2022). Pot Marigold will grow one to two feet tall and require full to partial sun. As an herb the petals are much prized for their coloring and flavor. The colonists used the petals to color butter and cheese and added the dry petals to soup for flavor (Gilman, 1999).

3.Snapdragon (*Antirrhinum majus*):

The unique **snapdragon**, with its dragon-face-like flowers, is a fascinating addition to winter gardens. These flowers, available in vivid colors, grow in clusters along tall spikes and emit a pleasant scent. Preferring temperatures between 18–24°C and moderate sunlight, snapdragons are both ornamental and medicinal, valued for their anti-inflammatory properties.

4.Sweet William (*Dianthus barbatus*):

For a touch of old-world charm, **sweet william** blooms in clusters of solid or patterned colors, exuding a musky fragrance. Growing up to 2 feet tall, these flowers require full sun and well-drained soil to thrive at 21–24°C. Aside from their garden beauty, they are used in perfumes and as edible garnishes. Similarly, **carnations** (*Dianthus caryophyllus*), known for their fringed petals, come in a variety of colors and thrive in 10–24°C. Carnations are prized for their elegance and therapeutic uses, such as nerve calming and anti-inflammatory effects.

5.Petunias (*Petunia* × *atkinsiana*):

They are trumpet-shaped blooms that bring cheer with their smooth or ruffled petals in both plain and striped patterns. These flowers grow up to 1.5 feet tall and thrive in temperatures of 12–26°C. Their lively colors attract pollinators and make them a staple for ornamental gardens. Meanwhile, **hollyhocks** (*Alcea rosea*) provide height and grace with their cup-shaped blooms in pink, white, and yellow shades, reaching an impressive 9 feet tall. These flowers are often used in wedding decorations and are believed to ward off negative energies.

6.Pansies (*Viola* × *wittrockiana*):

Adds a velvet-like texture to winter gardens with their five-petaled blooms in vibrant shades of yellow, violet, and pink. They are not just visually appealing but also edible, rich in Vitamins A and C, making them ideal for culinary use. Another showstopper is the **dahlia** (*Dahlia pinnata*), which, with its large and striking blooms, grows up to 5 feet tall. Dahlias are planted using tubers and are often used in landscape gardening, dye production, and food decoration.

 Marigold	 Calendula	 Snapdragon
 Sweet william	 Petunia	 Pansies
 Chrysanthemum	 Iceland poppies	 Larkspur

Winter's Floral Symphony: A Celebration of Seasonal Blooms

7.Chrysanthemum (*Dendranthema grandiflora*):

The radiant **chrysanthemum,** or "Guldavari," is a winter delight known for its dense, globular blooms in various sizes and colors. Its flowers are in various shades of yellow, white, having forms like single or double (Desai, 1962). Because annual chrysanthemum flowers are short-lived and produce marketable, attractive, and high-quality flowers, growers are drawn to them (Hawa et al., 2018). Thriving at 12–25°C, chrysanthemums are not only ornamental but also produce oils used as natural insect repellents. Equally captivating are **asters** (*Aster amellus*), with their long-lasting blooms featuring single or multi-petal rows around a yellow centre. These flowers grow up to 4 feet tall and thrive in temperatures of 15–30°C, adding elegance to any winter garden.

8.Iceland poppies (*Papaver nudicaule*):

Bring a delicate charm with their concave petals and vibrant stamens in shades of yellow, white, and orange. They grow well at 16–20°C and are often used for dye extraction and decorative purposes. For a mass of tubular blooms, **salvias (***Salvia officinalis*) are an excellent choice. Available in shades of violet, purple, and red, these 4-foot-tall plants thrive at 21–29°C and are sometimes used for mental and skin health remedies.

9.Larkspur (*Delphinium species*):

Finally, the dramatic **larkspur** stands tall with its vibrant blooms reaching heights of 6 feet. Thriving at 10–21°C, larkspurs are visually stunning but toxic due to alkaloids. They are used in making blue ink and medicinally as diuretics and vasodilators.

Winter flowers, each with unique characteristics, transform gardens into vibrant sanctuaries. From marigolds to larkspurs, these blooms not only beautify spaces but also serve various practical purposes, enriching both our surroundings and lives.

Conclusion

Winter flowers bring life and vibrancy to gardens and homes, defying the cheerful tones of the season with their striking hues and forms. Beyond their ornamental value, these blooms provide practical benefits such as medicinal properties, edible applications, and ecological contributions. With proper care, including adequate sunlight, optimal soil conditions, and regular feeding, gardeners can cultivate a wide array of winter flowers, from marigolds to larkspurs. These blossoms symbolize resilience and beauty, serving as a reminder of nature's ability to thrive even in the coldest months, enriching lives and environments alike.

References

Hawa, R. A., Gondane, S. U., and Panchbhai, D. M. (2018). Effect of planting time and pinching on the yield of annual chrysanthemum (*Chrysanthemum coronarium* L.). International Journal of Agricultural Science, 10(15), 6890-6892.

Desai, B. L. (1962). Chrysanthemum. In: Seasonal flowers, ICAR, New Delhi. pp. 64-65.

Brown, S. H., Mason, B., & Gardener, M. (2012). Colorful plant beds for South Florida and similar climates. *Lee County Extension, Fort Myers, Florida*, *239*, 533-7513.

Love, S. L., Noble, K., Parkinson, S. and Bell, S. (2009). Herbaceous ornamentals: annuals, perennials, and ornamental grasses. Short-Season, high altitude gardening, Pp. 1-16.

Kar, S., and Patra, S. (2022). A Review on Marigold (*Tagetes erecta* Linn): the Phytochemicals Present and its Biological activities. *Prayogik Raayan*. 6(4), 50-58

Gilman, E. F., & Howe, T. (1999). Calendula officinalis. *Cooperative Extension Service, Institute of Food and Agricultural Sciences*.

Patil, K., Sanjay, C. J., DoggALLI, N., Devi, K. R., and Harshitha, N. (2022). A Review of Calendula OfficinalisMagic in Science. *Journal of Clinical and Diagnostic Research*, *16*(2), 23-27.

Volume: 04 Issue No: 12

BLAST DISEASE OF SMALL MILLETS AND ITS MANAGEMENT

Article ID: AG-VO4-I12-03

***P. T. Sharavanan and M.Vaithiyalingan**

Centre of Excellence in Millets,Tamil Nadu Agricultural University

Athiyandal- 606 603, Tiruvannamalai Dt, Tamil Nadu

*Corresponding Author Email ID: saravananpt@tnau.ac.in

Abstract

Blast disease caused by *Pyricularia* fungal pathogens infects small millet crops and cause considerable yield loss. The fungal pathogen produces different kind of symptoms in the crops and appearance of spindle shaped lesion on leaf lamina is main characteristic symptom. Other than leaf symptoms, infection on neck regions noticed in finger millet as well as little millet. The pathogen has wider host adaptability and it can survive in many graminiceous weeds. The disease can be effectively managed by following cultural practices, weed free conditions and proper nutrient management and chemical application after notification of symptoms.

Keywords: Blast disease, small millets, alternate host, management

Introduction

Small millets are small-seeded cereal crops widely known for its nutraceutical importanceas well as food and fodder. The most frequently cultivated millets are finger millet (*Eleusine coracana* (L.) Gaertn.), foxtail millet (*Setaria italica* (L.) P. Beauvois), kodo millet (*Paspalum scrobiculatum* L.), little millet (*Panicum sumatrense* Roth ex Roem. and Schult.), proso millet (*Panicum miliaceum* L.), browntop millet (*Brachiaria ramosa* (L.) Stapf) and barnyard millet (*Echinochloa crusgalli* (L.) P.Beauvois). Millets are grown for both grain and feed in India. Despite being thought of as resistant crops, most millet is now vulnerable to numerous diseases due to climate change. While some millets illnesses occur occasionally in particular climatic settings and have less detrimental effects on the crop, many of them frequently manifest in severe forms under various climatic conditions and result in significant economic loss. There is more to fungal diseases than only bacterial and viral ones. Grain mold, ergot, smut, anthracnose, downy mildew, blast, rust, charcoal rot, foot rot, banded sheath blight, and sheath rot are significant fungal diseases that affect millets. The diseases negatively impact the yield and quality of the produce by infecting various plant sections, such as the root, stem, leaves, peduncle, or grain. These diseases assume different significances for seed production, certifications and marketing of millets

One of the most dangerous and damaging diseases that is prevalent in the world's major millet-growing regions is blast, which is brought on by *Pyricularia* spp. It is the primary natural production limitation that causes significant economic losses with varied degrees of harm, particularly in the cultivation of finger, pearl, and foxtail millet. The Tanjore delta of Tamil Nadu is where the finger millet blast was initially documented in India. While foxtail millet blast was recorded in 1917 by Nishikado from Japan (Nishikado, 1917), but in India, it was reported in 1919 from Tamil Nadu (McRae, 1920). *Pyricularia grisea* (Cooke.) Sacc. (Perfect stage: *Magnaporthe grisea* (Herbert) Barr] causing blast in finger and proso millet whereas *Pyricularia setariae* Y. Nisik. infects foxtail millet. Nonetheless, the *P. setariae* isolates that infect foxtail millet are distinct from those that infect rice, pearl millet, and finger millet. It is well recognized that *Pyricularia grisea* causes pearl millet blast disease.

Symptoms produced by *Pyricularia* spp

i. Finger millet

All stages of finger millet plants are susceptible to blast pathogen infection; immature seedlings are particularly vulnerable to the disease and exhibit a burnt appearance in the nursery when severely infected. *P. grisea* infects finger millet at various phases of crop growth, resulting in the development of common symptoms such as finger blast, neck blast, and leaf blast. The disease typically causes water-soaked, spindle- or diamond-shaped lesions on the leaf lamina, which are initially encircled by a chlorotic halo. The development of oval or diamond-shaped lesions with a grayish center and dark brown edges are typical indications of leaf blast. The crop appears burned from a distance when there is a serious infection because nearby lesions expand and may combine to form massive necrotic patches.

Neck blast is the most destructive stage of finger millet blast, where the virus attacks the neck area, lowering the weight and quantity of grain per earhead and causing earhead sterility. This causes the neck area two to four inches below the ear to turn brown at first, then black, and in a high humidity climate, olive gray fungal growth can be seen in the blackened area. When a finger blast occurs, the pathogen typically targets the apical regions of the finger that run toward the base. Finger blast infection causes seeds to become shriveled and blackened, rendering them unfit for human consumption due to the loss of vitamins and minerals.

ii. Foxtail millet

Foxtail millet leaf symptoms began as a tiny, water-soaked, yellowish dot that eventually grew into an oval or circular spot with a grayish core and a brown border. Within two to three days, spots had an average diameter of 2 to 5 mm. After that, the spots merged, causing the leaves to dry out. Beginning with the lower leaves, the illness spreads to the top leaves. There were no signs on the foxtail millet's neck. The leaves wither and dry out when the illness manifests in its most severe form during humid weather, particularly when there is a dense plant stand.

iii. Barnyard millet

Under field conditions, the symptoms of barnyard millet manifest on young seedlings. The dots vary in size and have a spindle to circular form. At first, the spots had a grayish center and a yellowish border. The centers later took on the hue of ash. In humid environments, fungus grows an olive-gray overgrowth in the middle of the spots.

iv. Little millet

The symptoms manifested as varying-sized, spindle-shaped lesions. The patches had a grayish center and yellowish edges at first. Later, the center turns ash-colored. An olive gray overgrowth of the fungus formed at the center when the environment was damp (Laxmi Rawat et al., 2016).

v. Proso millet

On the leaves, a great number of tiny specks grow into brown spindle-shaped patches. Later, ash-gray centers with brown edges formed. Culm turns black as well. Plants may lodge at these locations since these nodes are brittle. At the base of the panicles, brown to black dots first develop. These patches then become larger and frequently encircle the neck directly beneath the panicles. Mycelia, conidiophores, and conidia cover the diseased neck, which shrivels. Panicles do not appear when the neck blast is intense. Additionally, the spikelets are infected and eventually turn black. The panicles stay erect and the grains do not fill when neck infections start early. According to Singh and Prasad (1981), late neck infections cause half full panicles to lodge, seriously affecting the yield.

Alternate host

The pathogen is found in rice, wheat, foxtail millet, pearl millet, proso millet, finger millet, and others. It is possible for *P. grisea* isolated from finger millet to infect rice crops, but not the other way around. Similarly, *P. setariae* that was isolated from foxtail millet has the capacity to infect *Dactyloctaenium aegyptium*, finger millet, pearl millet, and wheat. Nonetheless, a variety of weed hosts that grow next to the cultivated plants may act as potential disease inoculum sources, giving the fungus a different means of survival. With more than 100 species, *Pennisetum* is a diverse genus. It is still unclear which *Pennisetum* species are susceptible to *Magnaporthe grisea* infection. The available information indicates that the pathogen infects principally *Pennisetum glaucum*, *P. macroforum*, *P. squamulatum*, *P. pedicellatum*, *P. ciliare*, *P. purpureum*. Other graminaceous hosts such as *Agrostis palustris*, *Brachiaria mutica*, *Eleusine indica*, *Cyperus rotundus*, *Eragrostis sp.*, *Panicum miliaceum* serve as collateral hosts for the pathogen.

Management

i. Cultural practices

The likelihood of disease occurrence can be decreased by a number of agricultural practices, including timely sowing, maintaining optimal plant populations and spacing, timely weeding, balanced fertilizer use, crop rotation, deep plowing during the summer, removing crop residues from the field, cleaning field bunds after crop season, uprooting and burning diseased plants from the field, controlling irrigation water from entering other fields, etc.

ii. Adjustment of date of sowing

The main goal of crop disease sowing date selection is to minimize the amount of time that the infectious agent is in contact with the host's susceptible stage. Blast severity is decreased by early seeding.

iii. Seed rate and disease free seeds

For the right plant density per unit area, the precise seed rate must be adhered to. The field's high plant density causes constant high humidity, low temperatures, a lack of aeration, and fast pathogen growth. Disease severity can be decreased by maintaining an ideal plant population in the field to lessen the accumulation of relative humidity. Since many plant pathogens are spread to the field through contaminated or infected seeds and seedlings, using pathogen-free seeds is essential to environmentally friendly plant disease prevention.

iv. Weeding and eradication of alternate and collateral hosts

Another crucial cultural practice for managing plant diseases and stopping their spread is field cleaning. Some of the finest places to find disease-causing organisms are plants and plant parts. The inoculum that is present on a small number of plants in the field may grow on the plant and eventually seem to trigger an epidemic the next season. In order to actively survive when the primary crop is not available, plant diseases typically employ weeds, wild host plants, or self-sown host plants. Thus, one of the most important hygienic cultural practices is to keep the field free of extra pathogen hosts. The prompt removal of these aids in the management of blast illness.

v. Nutrient management

A plant that receives adequate nutrition is far more resilient to disease attack than one that suffers from nutritional excesses or deficits. A plant that lacks nutrients will be under stress and thus more vulnerable to illness. Additionally, plants that receive excessive fertilizer treatments may become more prone to disease. There are numerous ways that nutrients might impact the crop-pathogen connection. The occurrence of blast and other diseases is decreased by controlling the amount of nitrogenous fertilizer.

vi. Use of chemicals

Chemicals are typically not utilized to treat diseases in millet crops due to the high expense of both labor and chemicals. But occasionally, it becomes essential to combine it with a resistant variety. The two main applications for fungicides are foliar spraying and seed treatment. Nevertheless, combining them results in improved management.

- Seed treatment with carbendazim @ 1 gm/Kg of seed.
- Spray any one of the fungicides viz., Carbendazim (0.2%) or Iprobenphos (IBP) (0.1%) or premixture fungicide (Carbendazim+Mancozeb) (0.1%), Ediphenphos (0.1%) or propiconazole (0.1%) or Tricyclazole (0.1%). First spray immediately after noticing the symptoms. Need-based second and third sprays at flowering stage at 15 days interval to control neck and finger infection in finger millet.

Conclusion

Blast disease infection becoming a serious disease in small millet due to increase in area under cultivation. The study of pathogen variability and cross infectivity is requires for effective management strategies and development of resistant varieties.

References

Laxmi Rawat, A. Nagaraja and Arun Bhatt. 2016. First report of leaf blast on little millet (Panicum sumatrense Roth ex Roemer and Schultes) from mid hills of uttarakhand, Journal of Mycopathological Research, 54(1): 145-147

McRae W. 1920. Detailed Administration Report of the Government Mycologist for the Year 1919-20. India: Madras Agric Dept; 1920

Nishikado Y. 1917. Studies on the Rice blast fungus, (I). Berichte des Ohara Instituts für Landwirtschaftliche Forschungen. 1(2):171-218

Singh, R. S. and Prasad, Y. 1981. Blast of proso millet in India, Plant Disease, 65; 442-443

Volume: 04 Issue No: 12

SINGLE BUD SEEDLING PRODUCTION TO ENHANCE SUGARCANE PRODUCTIVITY

Article ID: AG-VO4-I12-04

S. Saravanakumar*

Scientist (Agronomy) ICAR – Krishi Vigyan Kendra, MYRADA

Erode District, TamilNadu, India

*Corresponding Author Email ID: myradakvkagri@gmail.com

Introduction

Sugarcane (*Saccharum officinarum L*) is one of the most important sugar crop cultivated In India. India is the second largest producer of sugar after Brazil. Sugarcane crop occupies almost 2.67 % of the total cultivable area and contributing about 7.5 percent total agricultural production in the country (DAC, 2020). The farmers cultivating sugarcane is facing problems like quality planting materials in time, high input cost, and unavailability of labour in time to carry out the intercultural operations, harvesting etc., seed cane is the prime factor in conventional method of sugarcane cultivation which costs around 20 percent of total production cost. Roughly 6 – 8 ton of seed materials required to cover 1 ha area. Moreover, it requires transportation and poor germination percentage. To reduce the overall cost of cultivation and the dependency of high amount of planting materials, the alternate method been evolved in sustainable sugarcane initiatives called single bud seedling production.

Selection of sugarcane buds for healthier seedlings

- Healthy canes of 7 to 9 months old which have good internode length (7 to 8 inches) and girth.
- Avoid canes with disease infestation like fungus growth, spots etc.

- Remove buds from the selected canes using an implement called Bud Chipper
- Keep the cane on the plank and adjust it in such a way that a single bud is placed exactly below the cutting blade. When the handle is pressed, single bud chip comes off the cane.
- The chipped buds have to be treated with organic or chemical solutions.

Sett Treatment

- Sett treatment is important to treat the buds with various organic or chemical solutions before planting to avoid infestation. The buds can be treated in the following way
- Take a tub preferably made of aluminium or plastic.
- Pour 10 litres of water in the tub and dissolve the chemical or organic components
- Put the bud chips in a plastic or gunny bag and immerse the bag in the prepared solution for 10-15 minutes.
- The bud chips have to be dried for 2 -3 hours under shade and then used for nursery plantation.

Sett treatment device

It is the device invented by ICAR – SBI for effective treatment of setts by using vaccum pressure. The selected setts were taken in the container having lid with connector provision for connecting tube. The suspension to be treated with the setts was prepared and added to the container till the setts were immersed in the solution. The solution can be of any agrochemicals viz., fungicide/ insecticide/ growth regulator/ adhesives/ nutrients or microbials prepared in water. The container was closed airtight with its lid and the outlet from the lid was connected to the vacuum pump. Then the vacuum was applied slowly @ 100 to 300 mmHg for 15 to 20 minutes depending on the size of the machine, setts and combination of agro-inputs. Under vacuum, it removes air in the container and setts i.e. it creates negative pressure and then the vacuum was released slowly for 5-10 minutes which led to absorption of surrounding solution inside the tissue The absorption was confirmed by tissue bioassay in the decreasing order of buds, rind, cut ends, nodal and internodal stalk tissue. Also the absorption was found to be equal as overnight soaking. Then the same solution was repeatedly used for treating the next batches of setts on the same day and confirmed similar effect.

This method of sett treatment is an improved method over conventional application as sett soaking at different periods of time. This method of mechanized short-term treatment has advantages viz., rapidity, effectiveness, less cumbersome in handling material, capable of delivering more than one agrochemical/ microbes/ endophytes, uniform treatment with evenly dispersed chemical, economical as it consumes less chemical and suitability for large scale application under farmer's field condition.

Nursery

Young seedlings are raised in the nursery. It is better to establish a shade net for the purpose of nursery management. It is a fully covered structure meant to provide shade and create other favourable conditions like warm and wind free environment

- For raising the nursery, take-well decomposed coco-pith. Fill half of each cone in the tray with coco-pith.
- Place the buds flat or in a slightly slanting position in the cones of a tray. Do not press or push it hard. Ensure that the bud side faces up (Placing buds in half filled tray).
- Cover the bud chips in trays completely with coco-pith.
- After filling all the trays, place them one above the other and finally keep an empty tray upside down at the top. About 100 trays (4 sets, each consisting of 25 trays) are to be placed together and wrapped tightly with polythene sheets. Place small weights on the bundles and keep it for 5 to 8 days in the same position to create high temperature and humidity.
- Take measures to control termites around the trays by drenching the soil with Chlorpyriphos 50 EC (5ml/l) and ensure that there are no weeds in and around the nursery area.
- Care should be taken to avoid water, air or sunlight entering into the trays by tightly covering and keeping the bundles in shade net or preferably inside a room. Create artificial warmth through electric bulbs if the climate is too cold. This is the most crucial phase of the nursery management. Under proper conditions (especially, warm temperature) within 3 – 5 days, white roots (primodia) will come out and shoots will also appear in next 2 to 3 days.

- Either on the 5th or 8th day (based on the climatic conditions), all the trays with sprouted buds are to be removed from the polythene sheet and kept side by side in beds on the ground (see Annexure for the details on arrangement of trays) to facilitate watering and other nursery management practices.
- Based on the moisture content of coco-pith, watering to the trays (seedlings) has to be initiated in the evenings for the next 15 days using rose cans. Shoots will start growing strong and leaves will start sprouting. After appearance of two leaves, application of water can be increased gradually depending on moisture level in trays.

- During six leaf stage (about 20 days old seedling), grading of the plants has to be done. Stop giving water for a day to loosen the coco-pith in the trays, this enables easy lifting up of the young seedlings.

Reference

DAC. (2020). Pocket Book of Agricultural Statistics (2019). Directorate of Economics and Statistics, Government of India. New Delhi Pp. 122.

Volume: 04 Issue No: 12

OPTIMIZING NUTRIENT MANAGEMENT FOR HIGHER YIELD AND QUALITY OF SESAMUM (*SESAMUM INDICUM*)

Article ID: AG-VO4-I12-05

V. Tejaswi[1], B. Rajendra Kumar[2], S. Govinda Rao[3], S.Tirumala Reddy[4] and A. Upendra Rao[5]

[1]P.G Student, Department of Agronomy, Agricultural College, Naira, Acharya N.G Ranga Agricultural University

[2]Assistant Professor, Department of Agronomy, Agricultural College, Naira

[3]Assistant Professor, Department of Statistics and Computer Applications, Agricultural College, Naira

[4]Assistant Professor, Department of Agronomy, Agricultural College, Naira

[5]Professor, Department of Agronomy, Agricultural College, Naira, India

*Corresponding Author Email ID: tejaswivasarla18@gmail.com

Abstract

The growing of sesame (*Sesamum indicum* L.) is largely dependent on the addition of nutrients such as nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), sulfur (S), organic manures and biofertilizers. This review discusses the effect of nutrient management practices on yield of sesame. The availability of Nitrogen further promotes metabolism of carbohydrate as well as protein. Higher root density and uptake of phosphorus accelerated the essential nutrients that offered an increase in growth and yield attributes. Sulfur is required as it is involved in the metabolism of nitrogen and in amino acid synthesis thereby helps in improving yield. Use of organic amendments such as Farmyard manure and vermicompost have been shown to increase seed yield and oil content. Biofertilizers, especially the genera *Azotobacter* and *Azospirillum*, were also found to enhance seed yield and growth parameters of the plants when applied with the basal NPK fertilizers. What worked effectively were integrated nutrient management bundles targeting organic and inorganic sources. Quite interestingly, treatments such as 100% RDF combined with 100% organic inputs such as *Jeevamrut* or vermicompost significantly improved

oil content and yield. The synthesis highlights the rationale of balanced nutrient application for increasing sesame production. Therefore, the article's main goal is to explain the importance of sesame seeds, the production trend, the challenges faced and to offer an appropriate nutrient management program. By addressing these aspects, this research aims to offer farmers useful suggestions for enhancing yield and promoting food security.

Keywords: *Integrated nutrient management, Pseudomonas, Azospirillum, Azotobacter, Jeevamrut, Panchgavya, Vermiwash, Recommended fertilizer formula, Soil test-based fertilizer recommendation.*

Introduction

Sesamum (*Sesamum indicum* L.) is an important ancient oilseed crop in India designated as "Queen of Oilseeds". The crop thrives best on moderately fertile, well-drained soil with a pH range of 6.5 to 8.0, but it is sensitive to salinity. It contains 50-52 per cent oil, 17-19 per cent protein, 0.1- 0.5 per cent fatty acids and 16-18 per cent carbohydrates (Kahyaoglu and Kaya, 2006). Due to the presence of potent anti-oxidants, sesame seeds are called as the 'seeds of immortality'. Sesame oil is called 'poor man's ghee'. Sesame oil is valued for its anti-viral, anti-bacterial, and anti-fungal properties. Sesame cake, rich in proteins, calcium, phosphorus, and vitamin E, serves as valuable manure and nutritious feed for cattle. In India, sesame cultivated over 15.31 lakh ha area with 8.47 lakh tonnes of production and 553 kg ha^{-1} productivity (Indiastat 2023-2024). Though it is an important oil seed crop, the post green revolution scenario of Indian agriculture encompasses many problems such as deterioration of soil fertility, decline in production and productivity of major crops and increasing cost of production. Indiscriminate use of chemical fertilizers resulted in the deficiency of nutrients and disrupted natural nutrient equilibrium in soils. In order to promote crop establishment and health, it is necessary to limit the use of chemical fertilizers and pesticides in agriculture. As a result, organic practices, including the use of bio-fertilizers and enriched compost, offer a sustainable alternative by enriching soil with micro and macro- nutrients, promoting nutrient uptake, and reducing the dependence on expensive and environmentally harmful inorganic fertilizers.

Bio-Fertilizers achieve one of the necessary landmarks regarding the provision of the organic nutrients. These are however very eco-friendly solutions. They stimulate plant germination and growth by producing phytohormones and increasing the plant's capability to mobilize its nutrients. Foliar applications can enhance the processes of respiration, increase the activities of cells, and speed the synthesis of chlorophyll. The practice of top-dressing with liquid organic manure is urgent for enhancing crop productivity and yield. Panchgavya is an inexpensive organic solution that is composed of fermentative microorganisms such as lactobacillus, Azotobacter, phosphobacteria and yeast and almost all of the macro and micronutrients and plant growth hormones Wide's, IAA and GA are present (Praneeth *et al.*, 2021).

Vermicompost is the best organic fertilizer and serves as a soil conditioner and is also very rich in nutrients. The process of vermicomposting results in the increase of microbial diversity and activity dramatically and the vermicompost produced could be an ultimate source of plant growth regulators produced by interactions between microorganisms and earthworms which could contribute significantly to increased plant growth, flowering and yields (Arancon and Edwards, 2009; Jayashree *et al*., 2011). Vermiwash, the liquid product from earthworms, is obtained through the process of decomposing organic waste and microbes, which thrick the worms into secreting some of the enzymes along with other nutrients such as phytamines and vitamins. It is rich in nutrients which are essential for encourage plant growth. Balanced fertilization of high oil crop production includes the usage of nitrogen and phosphorus substances which build up the fertility of the soil and thus maximize the nutrient content of the plant. Fertilizers containing nitrogen and phosphorus, and biofertilizers such as Azotobacter or phosphates bacteria play important role among others in plant nutrition.

The vast majority of Indian soils do not have these microorganisms present and are therefore also low in nutrients. Mineral fertilizers, organic manure, and bio-fertilizers are the required materials for integrated nutrient management. To this end, the above shares knowledge of the seed production trend, production challenges, diseases, and growth enhancement through the sustainable management of nutrients. Indian soils are mostly in the deficit of nutrients, also their microorganisms are not so efficient. The best combination of the mineral, organic manures, and biofertilizers according to INM, are the ones that meet the needs of the issue. Probably, this work will result in the farmers having an idea of the use of the techniques of nutrient management and subsequently, improve the productivity and quality of sesame.

Effect of NPK on Sesame

Carbohydrate as well as protein metabolism is mediated by adequate nitrogen and this leads to cell division and cell elongation. Similarly, good supply of phosphorus is usually associated with increased root density and proliferation, which aid in extensive exploration and supply nutrients and water to the growing plant part, resulting in increased growth traits thereby ensuring more seed and dry matter yield (Maiti and Jana, 1985). Chauhan *et al.* (2016) concluded that application of 50% RDN recorded significantly higher values of all the growth and yield attributes as well as seed (1273 kg ha^{-1}), stover yield (2861 kg ha^{-1}) and oil yield (655 kg ha^{-1}). Similarly, the application of NPK fertilizer at 300 kg ha^{-1} gave the highest yield per hectare (617.1 kg and 615.8 kg in 2016 and 2017 cropping seasons respectively) which were significantly different from the other fertilizer rates (Eifediyi *et al.*, 2021a). Kumar *et al.* (2022) concluded that application of 90 kg N ha^{-1} resulted in significantly higher seed yield (525 kg ha^{-1}), stover yield (2372 kg ha^{-1}) and biological yield (2898 kg ha^{-1}).

Application of (60: 30: 30: 60 NPKS kg ha^{-1}) resulted in highest yield of sesame (Sharongmangyang *et al.*, 2019). Jose *et al.* (2021) concluded that application of NPK@ 75:50:30 kg ha^{-1}) increases seed yield by 857, 855, 850 kg ha^{-1}. Zenawi and Mizan (2021) reported that application of 46–100kg N ha^{-1} gives maximum yield. Motaka *et al.* (2016a) professed that higher yield of sesame (706 kg ha^{-1}) was recorded from the application of 75 kg N ha^{-1}. According to Noorka *et al.* (2011), the favorable impact of nitrogen in encouraging plant growth was responsible for the considerable rise in growth, yield and quality metrics of sesame with each increment in nitrogen content from 55 to 205 kg ha^{-1}. Deepthi *et al.* (2018) application of 125% RDF (M_3) along with foliar application of 19:19:19 @ 1.0 % at early budding stage followed by 1.0 % KNO_3 at early capsule formation stage recorded the highest seed yield (923 kg ha^{-1}) and stalk yield (2095 kg ha^{-1}) in North Coastal Zone of Andhra Pradesh. Chandrasekaran *et al.* (2024) resulted that the performance of rice fallow sesame was poor under zero-till conditions leading to a yield penalty of up to 68% in the southern plateau and hills region of the Indian sub-continent. Kankal *et al.* (2024) application of 100% RDN (25 kg ha^{-1}) resulted in significantly higher yield 6.99 (q ha^{-1}).

Sulphur is an essential nutrient for plant growth and crop production which is needed in relatively large quantities compared to micronutrients. It plays a critical role in protein synthesis, photosynthesis synthesis of essential oils and chlorophyll formation. According to Khan *et al.* (2016), sulfur application at 30 kg ha^{-1} gave maximum no of pods $plant^{-1}$, number of grains pod^{-1}, 1000 seeds weight and grain yield. Shilpi *et al.* (2012) found similar results, applying 60:40 kg N, S ha^{-1} in Bangladesh and recording the greatest plant height (112.20, 98.83

cm), number of branches plant^{-1} (11.47, 11.22), seeds capsule^{-1} (47.79, 47.77), and seed yield (1.31, 1.21 ha^{-1}). Sulphur fertilization in the acid *Alfisols* of Odisha exhibited improved yield (kg ha^{-1}), oil content (41.2) and nutrient uptake (N:55.77, P:26.18, K:37.09 and S:5.36 kg ha^{-1}) in sesame (Pattnayak *et al.*, 2024).

Effect of Organic manures on Sesame

Organic manures are natural fertilizers derived from plant or animal materials. They enrich soil health, improve its structure, and enhance nutrient content. Ganjineh *et al.* (2019) reported that application of manure and organic fertilizers resulted in higher seed yield by 24%, 22% and oil yield was 667 kg ha^{-1} and 720 kg ha^{-1}. The number of capsules per plant produced and yield obtained by sesame was significantly higher with guano fertilizer application (Dollison, M. D and Dollison, B. B. 2023). Labib *et al.* (2019) concluded that treatment of 100% of compost gave maximum values of number of plants ha^{-1} (119.80 thousand ha^{-1}) and seed yield plant^{-1} (15.37g). Eifediyi *et al.* (2017b) found that the addition of 3 tonnes neem seed cake ha^{-1} attained a maximum value of seed yield plant^{-1}. The protein content, oil content, oil yield and net returns were considerably higher than those of the other treatments when organic manures FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} and mineral nutrients S @ 20 kg + Fe @ 10 kg + Zn @ 5 kg ha^{-1} were applied (Choudhary *et al.*, 2017). According to Ahirwar *et al.* (2017), the highest seed, stover and oil yields were obtained with 100% RDF + 75% RDN through FYM (25%) + Vermicompost (25%) + Neem oil cake (25%) and were comparable to applying 150% RDF coupled with micronutrients (Zn and Fe) and *Azotobacter*.

Haruna and Aliyu (2011) discovered that through a three year field trial, that a 5 tonnes poultry manure ha^{-1} increase in sesame production was greater than other levels. According to Anguria *et al.* (2017), poultry waste showed a higher sesame protein concentration than other manures. When compared to other applied rates of sheep and cow dung, the application of poultry manure boosted the seed production (1914.07 and 1933.20 kg ha $^{-1}$ in 2008 and 2009, respectively). The use of 30 tonnes of chicken manure per hectare had a major impact on sustaining the development and yield of sesame, with a 47% oil content (Nurhayati *et al.*, 2016b). Pattnayak *et al.* (2024) conducted an experiment in Odisha and revealed that application of 100 % RDN through 50% of FYM and 50 % of vermicompost + remaining RDP through rock phosphate resulted in maximum uptake of nutrients by seeds and stover and also in increasing the productivity of summer sesamum.

Effect of Biofertilizers on Sesame

Biofertilizers are natural substances that contain living microorganisms, which enhance the availability of nutrients to plants. They promote soil health and fertility by improving nutrient uptake and supporting beneficial microbial activity. According to Jadhav *et al.* (2015), the inoculation of 600 g of seeds each with *Pseudomonas striata* and *Azotobacter chroococcum* produced the best value of seed yield plant^{-1} in a clay soil. Additionally, Subash and Rafath (2016) observed that the bacterial inoculum of *Azotobacter* produced the highest value of seed yield plant^{-1} followed by the bacterial inoculum of *Azospirillum*. Rafath concluded that biofertilizer treatment *i.e.*, *Azospirillum* have indicated the highest number of branches plant^{-1} (14.6), number of capsules plant^{-1} (37.33), maximum 1000 seed Weight (3.96) and seed yield plant^{-1} (3.12). The sesame yield in the treatments fertilized with 50-75% N of Recommended fertilizer formula (RFF) plus an individual strain of ASD-48, ASD-21, or their mixture was equivalent to or even higher than the results in the treatment fertilized with only 100% of RFF, 9.23-10.3g pot^{-1} compared to 9.47g pot^{-1} (Thuc *et al.*, 2022).

The higher number of average capsules plant^{-1} (21.48), seeds capsule^{-1} (50.94), 1000 seed weight (30.15g) and grain yield (8.91 q ha^{-1}) were obtained with the application of 75% soil test-based fertilizer dose (STD)+ *Azospirillum*, *Azotobacter* and *PSB* @ 4 kg each incubated with 300 kg of FYM ha^{-1} at 30% moisture for 7 days + Sulphur@30 kg ha^{-1} (Samant, 2020). Application of Vermicompost (2 t ha^{-1}) enriched with microbial consortia contain *Azotobacter* (2 L ha^{-1}) + PSB (2 L ha^{-1}) + KSB (2 L ha^{-1}) + *Trichoderma harzianum* (3 kg ha^{-1}) + *Pseudomonas fluorescens* (3 kg ha^{-1}) + *Beauveria bassiana* (3 kg ha^{-1}) increases seed yield (919 kg ha^{-1}), oil content (45.65%) and oil yield (419 kg ha^{-1}) on medium black calcareous soil under South Saurashtra Agro- climatic zone (Mokariya *et al.*, 2021). Vijaya Geetha *et al.* (2020) concluded that seed pelleted with Neem leaf powder 760 g + *Azospirillum* 120 g + Phosphobacteria 120 g + 10% Maida gruel increases No. of capsules (58.5), No. of Seeds per capsule (58.5) and seed yield of 530 kg ha^{-1}. ALCF: *Azospirillum lipoferum* + Half dose of chemical fertilizers treatment improved plant growth, seed yield and oil quality of sesame pertaining to good quality edible oil production (Nosheen *et al.*, 2019). Sahu *et al.* (2024) application of 75% RDF + 2 t ha^{-1} FYM + Jeevamrut @250 L ha^{-1} showed highest seed yield (652.21 kg ha^{-1}).

Effect of INM on Sesame

Integrated Nutrient Management (INM) is a holistic approach which includes combined use of organic and inorganic fertilizers, along with soil amendments, to optimize nutrient availability and enhance soil health. Application of 100% RDF + 2 t ha^{-1} FYM + *Jeevamrut* @250 L ha^{-1} gives the highest oil content 50.04% (Chakraborty *et al.*, 2021). Number of pods $plant^{-1}$ (100), Number of seeds pod^{-1} (64) and 1000 seeds weight (3.82g) was highest when 15 t ha^{-1} vermicompost + 70% RDF (N:21, P:11, K:14, S:5 kg ha^{-1}) was applied (Shathi *et al.*, 2023). The highest NPK uptake by seed (30.20, 7.52 and 6.74 kg ha^{-1}), stalk (27.68, 12.45 and 22.18 kg ha^{-1}) and seed yield (978 kg ha^{-1}) were recorded under the treatment of 50% RDF+5.0 t FYM ha^{-1} +PSB+ *Azotobacter* by Parmar *et al.* (2020b). Based on the experimental results, Parmar *et al.* (2022a) concluded that applying 100%RDF+1% banana pseudostem sap during the flowering and capsule formation stages, significantly enhances the growth, yields and higher nutrient uptake. Maximum yield attributes *viz.*, number of capsules $plant^{-1}$ (53.80), seed yield (516 kg ha^{-1}), capsule yield $plant^{-1}$ (45.21) and test weight (3.90 g) were produced due to application of 75% N (Urea) + 25% N (Poultry manure) reported by Lokhande *et al.* (2020).

Application of FYM @ 12.5 t ha^{-1} +50% RDF+ Panchagavya @ 3% foliar spray recorded significantly higher capsules $plant^{-1}$ (125.01), number of seeds $capsule^{-1}$ (83.69), 1000-seed weight (4.03 g), seed yield (1013 kg ha^{-1}) and stalk yield (3500 kg ha^{-1}) reported by Veeral and Nayakanti (2019). Similar findings were recorded by Shekhawat *et al.* (2021) that number of capsules $plant^{-1}$ (34.3), number of seeds $capsule^{-1}$ (45.1) and test weight (2.63g) was obtained with N:20, P:10, K:10, S:12.5 + FYM @ 4t ha^{-1} + *Azospirillum*. Pushpanjali *et al.* (2021) revealed that number of capsules per $plant^{-1}$ (35.2) and test weight (4.26 g) increased significantly with 50% RDN through urea + 50% through poultry manure + *Azotobacter*. Similarly, the application of 75% RDF + *Azotobacter* + PSB + KSB + VAM 0.25 Kg ha^{-1}, resulted in higher number of capsules $plant^{-1}$ (54.94), seed yield (1002 kg ha^{-1}), protein content (23.40 %) and oil content (47.44 %) (Rathod *et al.*, 2024).

According to Lakhran *et al.* (2015), 75% RDF + 5 t FYM ha^{-1} + Biofertilizer produced the maximum numbers of capsules $plant^{-1}$(54.86), seeds $capsule^{-1}$ (61.89), test weight (3.46 g), and seed yield (1186 kg ha^{-1}). According to Motaka *et al.* (2016 b), using 50% RDN from inorganic fertilizer and 50% RDN from vermicompost resulted in the maximum oil output (292 kg ha^{-1}) and oil content (47.55%). Singh *et al.* (2024) concluded that application of RDF (40: 20:

20) + Vermicompost @ 4 t ha^{-1} recorded highest available N, P, K content in soil and yield characters of sesame in the Bundelkhand Region of Uttar Pradesh. Mandviwala *et al.* (2024) revealed that application of 75% RDF+ castor cake (1t ha^{-1}) recorded higher crop yields and N uptake by grains and stover. Alemu and Lishan (2024) concluded that application of FYM @ 10 t ha^{-1} and NPSB fertilizer at 50 Kg ha^{-1} was advisable for sustainable sesame yield improvement in South Western Ethiopia. Nurhayati *et al.* (2024a) concluded that applying the combination of chicken manure (24.75 g) and inorganic NPK fertilizer (1.45 g N, 0.74 g P, 1.25 g K $plant^{-1}$) yielded the best effects on growth, yield, soil fertility, and it resulted in an impressive oil content of 54.51% in white sesame cultivar 'Sumberrejo 1' ('Sbr-1'). Application of compost @ 3.3 t ha^{-1}+ soil application of *Azotobactor* and PSB @10 kg ha^{-1}+ 3 foliar spray of liquid organic NPK + one foliar spray of liquid organic S was found beneficial for sesame production (Gabhane *et al.*, 2019). Seboka *et al.* (2024) concluded that application of 10 t FYM and 46 kg N ha^{-1} gives maximum seed yield (t ha^{-1}). Application of NPK @ 21:23:23 + Seed treatment with *Azospirillum* (600 g ha^{-1}) + Phosphobacteria (600 g ha^{-1}) recorded higher No. of seeds/capsule (77.62) and seed yield (930.12 kg ha^{-1}) (Saha *et al.*, 2024).

Conclusion

Based upon the above analysis, combination of 100% RDF + 2 t ha^{-1} FYM + *Jeevamrut* (250 L ha^{-1}) resulted in the highest oil content. Whereas, Farmyard manure (12.5 t ha^{-1}) + 50% RDF + *Panchagavya* @ 3% foliar spray increases the yield and 50% RDN through urea + 50% through poultry manure + *Azotobacter* also gives the better results to enhance the yield. Ultimately, the best treatment may vary depending on specific conditions such as soil type, climate, and crop management practices. However, combining approaches like INM generally yields the most sustainable results.

References

Ahirwar, K., Panda, S and Jyotishi, A. 2017. Optimisation of sesame (*Sesamum indicum* L.) production through integrated nutrient management. *International Journal of Current Microbiology and Applied Science*. 6:1701-1707.

Alemu, F and Lishan, T. (2024). Managing Integrated NPSB Fertilizers and Farmyard Manure to Improve the Sesame (*Sesamum indicum* L.) Yield in Guraferda Districts, Southwest Ethiopia. *Russian Agricultural Sciences. 50*(2): 131-141.

Anguria, P., Chemining'wa, G. N., Onwonga, R. N and Ugen, M. A. 2017. Effect of organic manures on nutrient uptake and seed quality of sesame. *J Agric Sci*. 9(7): 135-144.

Arancon, N. Q and Edwards, C. A. 2009. The utilization of vermicomposts in horticulture and agriculture. In *Proceedings of Indo-US Workshop on Vermitechnology in Human Welfare* (pp. 98-108). Coimbatore, India: Rohini Achagam.

Chakraborty, P., Bairagya, M. D., Sarkar, S., Gulati, J. M. L., Santra, G. H., Nayak, N and Sahoo, B. K. 2021. Effects of Irrigation and Nutrient Management on Summer Sesame (*Sesamum indicum* L.). *International Journal of Current Microbiology and Applied Sciences*. 10(10): 212-220.

Chandrasekaran, H., Ramesh, K., Yadav, P., Pasala, R., Sathiah, E., Indiragandhi, P and Kasirajan, S. 2024. Evaluation of rabi season sesame productivity from graded nutrient doses and tillage regimes in rice fallows of southern plateau and hills region of the Indian sub-continent. *PeerJ*. 12: e17867.

Chauhan, Sreedhar., Rao, V. P., Reddy, A. P. K., Jayasree, G and Reddy, S. N. 2016. Response of sesame (*Sesamum indicum L.*) to irrigation scheduling based on climatological approach and N fertigation levels. *Journal of Oilseeds Research*. 33(1): 38-44.

Choudhary, K., Sharma, S. R., Jat, R and Didal, V. K. 2017. Effect of organic manures and mineral nutrients on quality parameters and economics of sesame (*Sesamum indicum* L.). *Journal of Pharmacognosy and Phytochemistry*. 6(3): 263-265.

Deepthi, C., Ramana, A. V., Rao, A. U and Murthy, P. G.2018. Nutrient Management in Rabi Sesame for North Coastal Zone of Andhra Pradesh. *The Andhra Agric. J* 65 (3): 525-528.

Dollison, M. D and Dollison, B. B. 2023. Agronomic Performance of Sesame (*Sesamum indicum*) Under Different Fertilizer Management. *Biosaintifika: Journal of Biology & Biology Education.* 15(3): 378-385.

Eifediyi, E. K., Ilori, G. A., Ahamefule, H. E and Imam, A. Y. 2021a. The effects of zinc biofortification of seeds and NPK fertilizer application on the growth and yield of sesame (*Sesamum indicum* L.). *Acta agriculturae Slovenica.* 117(1): 1-11.

Eifediyi, E.K., Ahamefule, H.E., Remison, S.U., Aliyu, T.H. and Akanbi, N. 2017b. Effects of neem seed cake and NPK fertilizer on the growth and yield of sesame (*Sesamum indicum* L.). *Cercetări Agronomice în Moldova*. L (2): 57-72.

Gabhane, A. R., Gite, P. A., Khadse, V. A., Kadu, P. R and Patle, P. N. 2019. Production potential of organic summer sesame as influenced by compost, foliar nutrients and biofertilizers. *Journal of Pharmacognosy and Phytochemistry*. 8(2S): 47-50.

Ganjineh, E., Babaii, F., Mozafari, A., Heydari, M. M and Naseri, R. 2019. Effect of urea, compost, manure and bio-fertilizers on yield, percentage and composition of fatty acids of sesame seed oil (*Sesamum indicum L.*). *Cellular and Molecular Biology*. 65(5): 64-72.

Haruna, I. M and Aliyu, L. 2011. Yield and economic returns of sesame (*Sesamum indicum* L.) as influenced by poultry manure, nitrogen and phosphorus at Samaru, Nigeria. *Elixir Agric*. 39: 4884-4887.

Indiastat,2023.https://www.indiastat.com/table/agriculture/area-production-productivity-sesamum-india-1950-19/36611

Jadhav, S.R., Naiknaware, M.D. and Pawar, G.R. 2015. Effect of nitrogen, phosphorus and biofertilizers on growth, yield and quality of summer Sesamum (*Sesamum indicum* L.). *Int. J. Tropical Agric*. 33(2): 475-480.

Jayashree, S., Rathinamala, J and Lakshmanaperumalsamy, P. 2011. Determination of heavy metal removal efficiency of *Chrysopogon zizanioides* (Vetiver) using textile wastewater contaminated soil. (2011): 543-551.

Jose, Sandra., Pavaya, R. P and Malav, J. K. 2021. Effect of NPK and micronutrients on growth and yield attributes of sesame (*Sesamum indicum* L.) in loamy sand. *Green Farming*. 12(1&2): 43-5.

Kahyaogla T and Kaya S. 2006. Modelling of moisture, color and texture changes in sesame seeds during the conventional rusting. *Journal of Food and Engineering*.75:167-177.

Kankal, D. K., Nawlakhe, S. M., Khawale, V. S., Deshmukh, Y. V and Rathod, S. R. 2024. Effect of integrated nutrient management on yield and economics of summer sesame (*Sesamum indicum* L.). SP-8(10): 131-133.

Khan, N., Khalil, S. K., Amanullah, A. A., Ullah, Z and Ali, M. 2016. Effect of nitrogen and sulfur on yield and yield components of sesame (*Sesamum indicum* L.) in calcareous soil. *Pure and Applied Biology*. 5: 471-75.

Kumar, K. C., Maitra, S., Shankar, T., Panda, M and Sagar, L. 2022. Growth and productivity of sesame (*Sesamum indicum* L.) as influenced by spacing and nitrogen levels. *Crop Research*. 57(3): 190-194.

Labib, H. A., Hamza, M., Abbas, M. S and Fayed, S. A. 2019. Bio and Organic Fertilizers as an Alternative to Conventional Mineral Source on Sesame (*Sesamum indicum* L.) Production and Oil Quality in Egypt. *Egyptian Journal of Agronomy*. 41(2): 133-147.

Lakhran, H., Sadhu, A. C and Kumawat, S. 2015. Quality and yield potential of summer sesame (*Sesamum indicum* L.) as influenced by sowing time and nutrient management in middle Gujarat. *The Bioscan*. 10(3): 1409-1411.

Lokhande, N. R., Kalegore, N. K., Bangar, H.V and Wakchaure, B. M. 2020. Growth and yield attributes of sesame (*Sesamum indicum* L.) as influenced by different organic manures.*Journal of Pharmacognosy and Phytochemistry*. 9(6): 750-752.

Maiti, D and Jana, P.K. 1985. Effect of different levels of nitrogen and phosphorus on yield and yield attributes of sesamum. *Journal of Oilseeds Research*. 15(4):22-259.

Mandviwala, M. S., Tripathi, S., Gudadhe, N. N., Dudhat, M. S and Garde, Y. A. 2024. Optimizing Nitrogen Efficiency, Partitioning and Balance Using Different Ratios of Organic and Inorganic Fertilizers in Summer Sesame. *Indian Journal of Fertilisers*. 20(7): 678-684.

Mokariya, L. K., Vaja, R. P., Malam, K. V and Jani, C. P. 2021. Effect of microbial consortia enriched vermicompost on growth, yield and quality of summer sesame (*Sesamum indicum* L.). *Journal of Pharmaceutical Innovation*. 10(12): 974-977.

Motaka, G., Paramar, D and Patel, J. 2016a. Response of sesame (*Sesamum indicum* L.) to organic and inorganic sources of nitrogen in light textured soils of semi arid Bhal region. *An Int. Quarterly J. Life Sci.* 11(3): 1653-1658.

Motaka, G. N., Paramar, D. J., Kalola, A. D and Sadhu, A. C. 2016b. Influence of integrated nutrient management on yield, quality and soil status under kharif sesame (*Sesamum indicum* L.)-chickpea (*Cicer Arietinum* L.) crop sequence under Middle Gujarat condition. *An Int. Quarterly J. Life Sci*. 11(2): 1345-1350.

Noorka, I. R., Hafiz, S. I and El-Bramawy, M. A. S. 2011. Response of sesame to population densities and nitrogen fertilization on newly reclaimed sandy soils. *Pak. J. Bot*. 43(4): 1953-1958.

Nosheen, A., Bano, A., Naz, R., Yasmin, H., Hussain, I., Ullah, F and Tahir, A. T. 2019. Nutritional value of *Sesamum indicum* L. was improved by Azospirillum and Azotobacter under low input of NP fertilizers. *BMC plant biology*. 19: 1-12.

Nurhayati, D. R., Taryono, T., & Hanudin, E. 2024(a). Integrated uses of organic and inorganic fertilisers to increase sesame productivity on coastal sand fields. *Journal of Water and Land Development*, 150-156.

Nurhayati, D. R., Yudono, P and Taryono, H. E. 2016(b). The application of manure on sesame (*Sesamum indicum* L.) under coastal sandy land area in Yogyakarta, Indonesia. *Int Res J Eng Technol*. 3(4): 2047-2051.

Parmar, S. K., Vihol, K. J., Dudhat, M. S., Usadadia, V. P and Tandel, B. B. 2022a. Response of integrated nutrient management on productivity, profitability, and quality of summer sesamum. *The Pharma Innovation Journal*. 11(7): 2000-2003.

Parmar, N., Jat, J. R., Malav, J. K., Kumar, S., Pavaya, R. P and Patel, J. K. 2020b. Effect of different organic and inorganic fertilizers on nutrient content and uptake by summer sesamum (*Sesamum indicum* L.) in loamy sand. *Journal of Pharmacognosy and Phytochemistry*. 9(3): 303-307.

Pattnayak, A., Mishra, G., Sar, K., Chowdhury, M. R and Behera, S. D. 2024. Effect of Different Organic Nutrient Sources on the Growth and Yield of Summer Sesamum (*Sesamum indicum* L.). *Journal of Advances in Biology & Biotechnology*. 27(7):400-407.

Praneeth, M., Singh, R and Singh, E. 2021. Response of late sown wheat [*Triticum aestivum* (L.)] to organic and liquid manures on yield and economics. *The Pharma Innovation Journal*. 10(10):1488-1490.

Pushpanjali, L. R., Bijarnia, A and Bijarnia, S. L. 2021. Yield, nutrient uptake and economics of sesame (*Sesamum indicum* L.) as influence by integrated nitrogen management under semiarid condition of Rajasthan. *INDIAN SOCIETY OF AGRICULTURAL SCIENCE*. 83.

Rafath, H. Effect of phytohormones and biofertilizers on productivity of sesame (*Sesamum indicum* L.). *Recent Innovations in*. 177.

Rathod, A.D., Thanki, R.B and Seta, S.N. 2024. Enhancing summer sesame (*Sesamum indicum* L.) productivity through integrated nutrient management: A comprehensive approach for sustainable agriculture. *Int Res J Modernization Eng Technol Sci*. 6(1):35-8.

Saha, A., Dasgupta, K and Mahanty, A. 2024. Impact of Integrated Nutrient Management on Growth and Yields of Sesame (*Sesamum indicum* L.) at Lower Gangetic Alluvial Zone of West Bengal. *International Journal of Plant & Soil Science*. 36(8): 779-786.

Sahu, G., Bhuyan, B., Mishra, S., Panda, D and Bebarta, A. A. 2024. Effect of Irrigation and Nutrient Management Studies on Sesame (*Sesamum indicum* L.). *International Journal of Plant & Soil Science*. 36(2): 81-95.

Samant, T. K. 2020. Effect of biofertilisers and sulphur on growth, yield, economics and post-harvest soil chemical properties in sesame (*Sesamum Indicum* L.). *Chem Sci Rev Lett*. 9(34): 475-480.

Seboka, E., Demisie, W and Shiferaw, T. 2024. Agronomic and Economic Evaluation of Mineral Nitrogen Fertilizer and Farm Yard Manure on Production of Sesame (*Sesamum indicum* L.) in Southeast Ethiopia.

Sharongmangyang, S and Nongmaithem, D. 2019. Effect of levels of nutrients (NPKS) on growth and yield of sesame (*Sesamum indicum* L.). Environment and Ecology 37(4): 1124—1127.

Shathi, T. A., Syed, M and Rahman, M. K. 2023. Growth and quality characteristics of sesame (*Sesamum indicum* L.) as influenced by vermicompost and chemical fertilizers. *Journal of the Asiatic Society of Bangladesh Science*. 49(1): 43-53.

Shekhawat, R. K., Yadav, L. R., Garg, K and Meena, B. L. 2021. Effect of integrated nutrient management on yield, nutrient uptake and profitability in sesame (*Sesamum indicum* L.). *INDIAN SOCIETY OF AGRICULTURAL SCIENCE*. 42 (1): 88-95.

Shilpi, S., Islam, M. N., Sutradhar, G. N. C., Husna, A and Akter, F. 2012. Effect of Nitrogen and Sulfur on the Growth and Yield of Sesame. *International Journal of Bio-resource and stress Management*. 3(2): 177-182.

Singh, A., Kumar, D., Sah, D., Mishra, A and Gupta, A. K. 2024. Effect of Organic Manures on Soil Nutrients, Growth and Yield of Sesame (*Sesamum indicum* L.) in Bundelkhand Region of Uttar Pradesh. *Journal of the Indian Society of Soil Science*. 72(1): 126-130.

Subash, M. and Rafath, H. 2016. Effect of plant growth promoters and biofertilizers on yield and yield components of sesame (*Sesamum indicum* L.). *Life Sci. Archives (LSA)*. 2(4): 622-627.

Thuc, L. V., Huu, T. N., Ngoc, T. M., Hue, N. H., Quang, L. T., Xuan, D. T and Khuong, N. Q. 2022. Effects of nitrogen fertilization and nitrogen fixing endophytic bacteria supplementation on soil fertility, N uptake, growth, and yield of sesame (*Sesamum indicum* L.) cultivated on alluvial soil in dykes. *Applied and Environmental Soil Science*. 2022(1): 1972585.

Vijaya Geetha, V., Sathiya, K and Harisudan, C. 2020. Efficacy of botanicals and biofertilizers in sesame seed treatment. *IJCS*. 8(3): 1252-1254.

Veeral, D and Nayakanti, G. 2019. Effect of integrated organic nutrient management (INM) practices on plant architecture and yield of sesame (*Sesamum indicum* L.). *Crop Research.* 54 (5and6): 126-130.

Zenawi, G and Mizan, A. 2019. Effect of nitrogen fertilization on the growth and seed yield of sesame (*Sesamum indicum* L.). *International Journal of Agronomy.* 2019(1): 5027254.

Volume: 04 Issue No: 12

FROM CRISIS TO INNOVATION: COMBATTING CLIMATE CHANGE'S IMPACT ON CROP PRODUCTION

Article ID: AG-VO4-I12-06

Vijay Gahlaut[1*], Vandana Jaiswal [2], Sundeep Kumar[3]

[1]Department of Biotechnology and University Center for Research and Development, Chandigarh University, Gharuan, Mohali, India

[2]Biotechnology Division, CSIR-Institute of Himalayan Bioresource Technology, Palampur, India.

[3] Indian Council of Agricultural Research (ICAR)-National Bureau of Plant Genetic Resources, New Delhi, India

*Corresponding Author Email ID: zone4vijay@gmail.com

Introduction

Climate change is reshaping ecosystems across the globe, and its effects on agriculture are particularly pronounced. Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events disrupt the delicate balance needed for productive farming. Agriculture has adapted to the natural rhythms of climate and weather for centuries. However, the accelerated changes we are witnessing today require a new level of adaptation, innovation, and resilience.The stakes are high: crop yield and food production stability are fundamental to feeding the world's growing population. As climate change continues to threaten the consistency of crop yields, food security hangs in the balance. Researchers, policymakers, and farmers are working together to confront these challenges, exploring innovative solutions to adapt crops to new environmental stresses and ensuring stable food supplies.

In this article, highlights are made on how climate change affects crop yields and the advanced agricultural solutions being implemented to mitigate these effects, aiming to secure global food resources for generations to come.

Effects of Climate Change on Crop Yields

Temperature Fluctuations

One of the most direct effects of climate change on crops is through temperature changes, particularly in the form of heat stress. Higher temperatures influence plant physiology, accelerating growth cycles, which often leads to smaller and less nutritious crops. Heatwaves during crucial periods like flowering can lead to poor grain or fruit development, reducing overall crop productivity. Crops such as wheat, rice, and corn are particularly vulnerable to these temperature shifts, and the associated risks of premature growth or stunted development are increasingly common in regions experiencing hotter and longer summers. Consequently, temperature fluctuations threaten the yields of essential crops and thereby the livelihoods of farmers and food availability for communities worldwide.

Altered Rainfall Patterns

Climate change is also disrupting precipitation patterns, creating unpredictable rainfall events that oscillate between droughts and floods. Drought conditions deplete soil moisture, inhibiting crop growth and reducing yields, especially for crops that are rain-fed. Conversely, excessive rainfall results in flooding, which can damage roots, deplete soil nutrients, and erode the soil, further limiting crop productivity. This inconsistency in rainfall patterns is particularly challenging for regions with a high dependency on rainfall for crop irrigation, such as parts of Sub-Saharan Africa and South Asia. As these regions often lack the resources to implement large-scale irrigation infrastructure, even slight shifts in rainfall can result in significant yield losses.

Increased Pests and Diseases

Warmer temperatures and changing climates enable pests and plant diseases to expand into new regions and thrive for extended periods. Pests such as the fall armyworm, previously contained within certain climates, are now infesting crops in previously unaffected areas, causing extensive damage to yields. Additionally, diseases caused by fungal pathogens, such as wheat rust and late blight in potatoes, have increased in frequency due to warmer, more humid conditions. Farmers face increased costs and labor-intensive management requirements to combat these threats, which further strains food production systems.

Soil Degradation

Extreme weather events, like intense rainfall and prolonged droughts, contribute to soil erosion, nutrient depletion, and salinization. These issues collectively degrade soil health, impacting crop productivity and long-term agricultural sustainability. As soil quality declines, crop yields suffer, creating a ripple effect that puts pressure on the food supply chain. Soil degradation due to climate change also presents a cyclical problem, as weakened soils are more susceptible to erosion, nutrient loss, and other damage, perpetuating a downward trend in yield potential and farming viability.

Advancements to Combat Climate Change's Impact on Crops

Climate-Resilient Crop Varieties

Agricultural scientists are developing crop varieties that are more resilient to environmental stressors, such as heat, drought, and floods. These resilient crops are often the product of traditional breeding techniques combined with advanced biotechnology and genetic engineering. For example, drought-resistant varieties of rice and wheat are specifically designed for arid regions, and "scuba rice," a type of flood-tolerant rice, can withstand prolonged submersion. New gene-editing technologies, such as CRISPR, enable scientists to expedite the development of these resilient crop varieties, helping farmers in vulnerable areas maintain yield levels despite harsh conditions.

Precision Agriculture and Smart Irrigation

Precision agriculture uses data-driven insights, sensors, and artificial intelligence (AI) to monitor crop health, soil conditions, and water requirements in real-time. Smart irrigation systems, such as drip irrigation and automated sprinklers, ensure that water is delivered precisely when and where it is needed, conserving water and reducing the impact of irregular rainfall. These technologies help optimize resource use, allowing farmers to maintain crop yields while adapting to variable weather conditions. Precision agriculture can also predict the best planting and harvesting times based on environmental conditions, reducing waste and increasing efficiency in farming operations.

Sustainable Soil Management

Improving soil health is a critical component of climate-resilient agriculture. Techniques like conservation tillage, cover cropping, and crop rotation enhance soil structure, increase its ability to retain water, and reduce erosion. Conservation tillage, for example, minimizes soil disturbance, maintaining a protective layer of organic matter that guards against erosion. Additionally, biochar, a carbon-rich soil additive, is gaining popularity for its potential to improve soil fertility and capture atmospheric carbon, aiding both crop production and climate mitigation.

Agroforestry and Integrated Farming Systems

Agroforestry involves integrating trees and shrubs into agricultural systems, providing a range of benefits including soil stabilization, increased water retention, and enhanced biodiversity. Trees act as windbreakers, reduce soil erosion, and can help moderate extreme temperatures, which benefits both crops and livestock. Integrated farming, combining crops with livestock or aquaculture, diversifies revenue streams for farmers, reducing the financial risk associated with crop failures and enhancing the sustainability of agricultural systems. Both agroforestry and integrated farming systems encourage biodiversity and help protect the soil, creating more resilient and adaptable ecosystems.

Digital Climate Services and Early Warning Systems

Advances in climate prediction and early warning systems provide valuable information to farmers, enabling proactive responses to impending weather changes, pest outbreaks, and optimal planting windows. Digital platforms and mobile apps deliver real-time data on rainfall, temperature trends, and other climate indicators, empowering farmers to make informed decisions. For instance, digital advisories on irrigation scheduling, based on precise weather forecasts, help farmers optimize water usage, while pest forecasts enable timely intervention. These services are instrumental in allowing farmers to anticipate and respond effectively to climate-related challenges.

Carbon Farming and Incentive-Based Policies

Carbon farming initiatives encourage agricultural practices that reduce greenhouse gas emissions and increase carbon sequestration in soil. Farmers who adopt carbon-farming practices contribute to climate mitigation while enhancing soil health and productivity. Policies and programs that provide subsidies, financial incentives, or carbon credits are increasingly implemented by governments and international organizations to encourage sustainable practices. By promoting carbon farming, these policies support climate adaptation efforts while rewarding farmers for their contributions to environmental sustainability.

Conclusion

The effects of climate change on crop yield present a serious threat to global food security, underscoring the need for innovative solutions and concerted efforts to sustain agricultural productivity. Advances in climate-resilient crops, precision agriculture, sustainable soil management, agroforestry, and digital climate services offer a promising pathway forward.

These innovations not only mitigate the direct effects of climate change but also promote more sustainable and adaptable agricultural systems.

However, ensuring that these advancements reach the farmers who need them most—especially smallholder farmers in vulnerable regions—remains a key challenge. Ongoing research, public policy support, and investment in agricultural resilience are essential to scale these solutions globally. By combining these strategies with support for farmers and local agricultural systems, the global community can create a robust agricultural sector capable of adapting to shifting climates, securing food resources for a growing population, and building a sustainable future.

Volume: 04 Issue No: 12

EMPOWERING AGRIPRENEURSHIP IN INDIA: INNOVATIONS DRIVING CHANGE IN AGRIBUSINESS

Article ID: AG-VO4-I12-07

Mr. Parth M Suriya*

Department of Agricultural Extension Education, College Of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) – 362002, India

*Corresponding Author Email ID: parthsuriya1@gmail.com

Abstract

India's agriculture sector is undergoing a transformative shift, driven by technological advancements and entrepreneurial innovation. Challenges like inefficiencies, fragmented markets, and climate risks are being addressed through solutions such as precision farming, drones, hydroponics, and blockchain-enabled platforms. These innovations enhance productivity, reduce post-harvest losses, and streamline supply chains while empowering farmers and fostering sustainable practices. Success stories of startups demonstrate their role in creating transparent markets, improving resource management, and supporting urban agriculture. The article highlights the need for skill development, financial incentives, and collaborative efforts to build a robust agritech ecosystem. This transformation is paving the way for agriculture to become a resilient, sustainable, and profitable enterprise, redefining the future of agribusiness in India.

Keywords: Agripreneurship, Agritech Innovations, Sustainable Agriculture

Introduction

Indian agriculture is the backbone of the Indian economy but due to structural issues, unorganized supply chain networks and climate change, the sector has not been able to reach its full potential. Old methods of farming are not enough, which makes it necessary for farming to adapt and innovate. Today the agritech sector is rapidly expanding due to new technologies such artificial intelligence, IoT and blockchain which aim to improve productivity, sustainability and transparency in the market. Tools like precision agriculture and blockchain networks are bettering resource use and connecting farmers to markets. More of the time, the agripreneurs and the start ups such as DeHaat and UrbanKisaan are changing the industry by integrating services like agriculture advice over the web and eco-friendly urban agriculture. The purpose of the present paper is to analyze how these startups and innovations are solving important problems in Indian agriculture in the hope of creating an efficient, technology-enabled agriculture environment.

Materials and Methods

This study adopts a qualitative perspective; it conducts literature review, case study, and analyses industry reports to understand the role of agripreneurs and enterprenuers in revamping India’s agricultural system. It deals with agritech advancements including precision farming, drones, blockchain and urban farming, sourcing from startup profiles including DeHaat, UrbanKisaan and Fasal. The research covers the villages and cities in India especially in the states of Punjab, Maharashtra and Telangana where these technologies are in use. They also built upon the literature derived from the *Journal of Agritech Research* and FAO sources regarding the innovations. The Software programs and platforms discussed include CropIn, Fasal, and Ninjacart with particular interest on the comparative effect of the relevant technologies on the agriculture’s prospects.

Results

The survey found that agritech development jointly with crops like precision farming practices, drones, and urban farming techniques have enhanced the productivity and the sustainability of the Indian agricultural sector. IoT and AI technologies were of help to the farmers in managing resources which translated to better yields. Drones improved performance by enabling the performance of certain functions, such as pesticide spraying, to be carried out automatically, rather than manually. Hydroponics and other urban farming systems saved water and also allowed for farming in cities. There was a reduction in wastage due to the digitalization of the supply chain and blockchain technology increased transparency in the trade of agricultural products. Digital platforms like DeHaat and UrbanKisaan also increased the accessibility of markets for the farmers.

Discussion

The results indicate the potential of agritech solutions towards addressing India’s agricultural issues. Different problems such as inefficient use of resources and loss in productivity have practical solutions in emerging technologies, namely precision farming, drones and many others. Where urban agricultural practices do not succeed, improvements in supply chain predictions provide hope for sustainable food systems. The growth of agritech start-ups attests to the role technology plays in closing the gaps within a system and improving the livelihoods of farmers. Once more, together with some policy back-up, these technologies have the capacity to promote growth as well as sustainability of the Indian agricultural sector for the foreseeable future.

Conclusion

This research shows that Indian agriculture is being revolutionized by the use of precision farming, drones, urban farming and other such innovations in agritech. Entrepreneurs such as DeHaat and UrbanKisaan are instrumental in uplifting farmers and returns on investment through addressing challenges faced in the sector. It is concluded that the dissemination of these technologies combined with scope for collaboration will be imperative in securing the sustainability and resilience of Indian agriculture in the years to come.

References

FAO. (2020). The State of Food and Agriculture.

Kumar, R., Singh, P., & Sharma, M. (2021). Role of IoT in Precision Agriculture: Opportunities and Challenges. Journal of Agritech Research, 15(3), 45-52.

Patel, A., Gupta, S., & Verma, R. (2020). Enhancing Crop Yield Through Smart Farming Solutions. Agriculture and Technology Review, 12(1), 23-29.

Singh, K., & Sharma, L. (2019). Blockchain in Agriculture: A Case Study Approach. International Journal of Sustainable Farming, 8(2), 19-26.

Gupta, S., & Verma, A. (2022). Transforming Agriculture through Blockchain: Opportunities in India. Indian Journal of Agribusiness Management, 10(4), 75-88.

Volume: 04 Issue No: 12

MICROGREENS AS IDEAL SUPERFOOD AND BOONS OF THE NEXT GENERATION

Article ID: AG-VO4-I12-08

***Farooq Ahmad Khan[1], Saddam Hussain[1], Mohammad Amir[2] and Moinuddin[3]**

[1]Sher-e-Kashmir University of Agricultural Sciencesand Technology of Kashmir, Shalimar, Srinagar – Kashmir (J&K), INDIA; [2]LPU, Phagwara, Punjab, INDIA,

[3]SGRR University, Dehradun, INDIA

*Corresponding Author Email ID: drkhanfa1966@gmail.com

Introduction

Microgreens originated in California, and creative chefs began using them in new dishes, adding color, flavor, texture, and interest to their dishes. Microgreens are vegetables grown after the cotyledons have emerged and may have developed true leaves (Figure 1). They are used as food products, visual aids, and for flavor and texture. Microgreens are reported to contain 4 to 40 times the nutritional value of plants grown on the plant. They are also good for the heart. Microgreens can add sweet and spicy flavors to foods. Microgreens are smaller than "baby greens" because they are harvested right after the plant sprouts, rather than after it has grown and produced many leaves. They can also be used as a main vegetable in some recipes for their intense flavor and nutritional value. Many recipes use them as a garnish, while others use them as the main ingredient. For example, pea sprouts with garlic in cabbage soup, pea sprouts or bok choy, or cabbage salad with radish sprouts instead of kale. Because they require little space during the growing season, they can be grown indoors, or even on a sunny windowsill. On a larger scale, microgreens are a profitable crop that lends itself to soilless production methods and hydroponic systems, providing quality, clean, and sand-free products.

Microgreens have three main parts: the central stem, the cotyledons or leaves, usually the first pair of young true leaves. Sizes vary depending on the particular plant, with sizes ranging from 1 to 1.5 inches (25 to 38 mm) in total length. Once the plant gets too large, it should not be considered a microgreen. Larger vegetables are called microgreens.

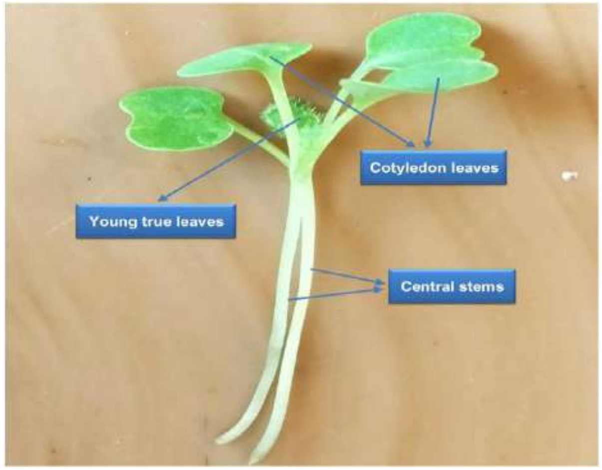


Figure 1. Microgreens

The average time from planting to harvest for fast-growing microgreens, such as many brassicas, is 10–14 days. Slow-growing microgreens, such as Swiss chard, beets, and many herbs, take 16–25 days to reach full size. There is no legal definition of either baby greens or microgreens. The terms "baby greens" and "microgreens" are trade terms used to describe the group. Sprouts are sprouted seeds that are usually eaten as a whole plant (roots, seeds, and sprouts), depending on the species. For example, almond, squash, and pistachio sprouts taste better when harvested before roots form. Bean sprouts are legal and are subject to additional regulations for production and marketing due to the high risk of microbial disease compared to other green vegetables. Growers interested in producing seeds for commercial use should understand the risks and precautions outlined in the FDA announcement (FDA 1999). As many as 80–100 products have been reported to be used as microgreens, and numerous products have been used as microgreens (Figure 3). Other plants used include carrots, watercress, arugula, basil, onion, chives, broccoli, fennel, lemongrass, popcorn, buckwheat, spinach, peas, and celery. Commercialization of microgreens is generally geared toward professional chefs or high-end food retailers. The product comes in resealable plastic containers and typically weighs 4-8 ounces, but is also sold in 1-pound containers.

What types of microgreens can you grow?

There are four main types of microgreens, all of which grow well and easily in a hydroponic system. They can thrive in both outdoor and indoor environments, making them excellent candidates for container farms.

- **Sprouts and sprouts:** You'll find bean sprouts, sunflower sprouts, and corn sprouts in this category. These types of microgreens are often used as garnishes, but their flavor is mild enough to complement any food without overpowering it.

- **Spicy Greens:** A small type of microgreens coats the plant in intense flavor. These microgreens have a sharp, crunchy, "peppery" flavor that most people either love or hate. Microgreens like cress, arugula, radish, and mustard greens.
- **Micro herbs:** These microgreens are often used as a garnish or side dish on a plate, but they are also known for their flavor and can be used to add flavor to many dishes and dishes. This group includes parsley, fennel, chrysanthemum, cilantro, basil, sorrel, mint, dill, chives, onion, and shiso.
- **Tender Greens:** These microgreens can be a group of four with a variety of flavors. Red cabbage, broccoli, spinach, corn salad, endive, chicory, celery, carrots and lettuce, as well as tatsoi, mizuna, amaranth, chard and kale also fall into the kids' vegetable category.

Figure 2. Soil versus hydroponic microgreens

Why hydroponic?

The main advantage of using hydroponics is that there is no need to use a growing medium. Because you are using high density seeds and planting microgreens, you don't have to have small pieces of substrate or soil that will get to your plants. Since microgreens are usually not washed after harvest, this can lead to crunchy grains in your food. Here are some other reasons to grow microgreens hydroponically:

- **Can be grown all year round:** Enjoy fresh microgreens even during the colder months.
- **Grow anywhere:** Hydroponic setups can thrive in many locations; your basement, garage, attic, even a shipping container.
- **Maximum space:** Hydroponic plants can be planted all year round, placed vertically to increase height, and planted together for more.
- **Easier growing:** Easier and better, you can set up a countertop garden in your kitchen
- **Less water:** You can reuse water in hydroponic systems, meaning they require 20 times less water. Growing in water is better than growing in soil.
- **More control:** Growing microgreens hydroponically means you have complete control over the nutrients your plants receive. You can adjust the amount of fertilizer for each microgreen you grow.
- **No Composting:** You don't have to worry about getting dirt all over your house or a bowl of dirt spilling onto your carpet. You also don't need a place to dump all your soil, so hydroponics is great for indoor growing.
- **No Soil-borne Diseases:** Most diseases that affect crops are soil-borne. When you remove soil from your farm, you also eliminate soil-borne pathogens that can harm your crops.
- **Some microgreens grow well in hydroponics:** Some microgreens, such as wheatgrass, kale, and kohlrabi, prefer hydroponics and produce better results than growing in soil.
- **Higher yields:** Due to the multi-year cycle, vertical stacking, and closer spacing, the average annual yield per hectare of hydroponic farming can be many times higher than with soil that has always been there

Best hydroponic microgreens for beginners to grow

If you're new to growing microgreens hydroponically and want to add variety and value to your business or just want to experiment, here are the best microgreen options to get you started. They all believe in bold, ornate, and easy-to-write stands. Together, they come in a variety of flavors, from mild to spicy, with beautiful colors and shapes and a variety of tastes and textures.

- **Basil:** A colorful combination of purple, variegated, and green leaves. A sweet and unique decoration.
- **Mustard:** Small but with a distinct mustard flavor. Black cotyledons contrast with the

green.

- **Radishes:** One of the fastest growing microgreens. Bright red stems. Radishes are long and add weight and volume to the micromix.
- **Cress:** Spicy, peppery flavor. Unusual three-lobed leaves. A fast-growing option for growers of all abilities.
- **Coriander:** Frilled leaves. Flavor is clean, fresh and mild. Start with an embryo, as it germinates more easily than the whole cilantro and loses its skin more easily.

Setting up a hydroponic microgreens system

These microgreens can be grown in a variety of difficult conditions, depending on your abilities and goals. From ordinary flat, hand-watered kitchen dishes to sophisticated aeroponic or nutrient film systems with carefully controlled environments arranged vertically in state-of-the-art controlled shipping containers.

- **Seed selection -** always start your green organisms from special seeds. plant growing seeds. These seeds have a high rate of problem-free plants and are not treated with fungicides or other chemicals. This is especially important if you plan to plant corn, pea or spinach microgreens (these seeds are often sprayed with fungicides). The seeds of some types of microgreens are mucilaginous, meaning that when the seeds are wet, they form a thick gelatin-like layer that retains moisture. Cress and basil are examples of slimy seeds. No pre-soaking is required before planting.
- **Germination and planting -** Microgreen seeds need light and nutrients to produce the best yield once they have germinated. Exposure lights are great at this stage as long as they do not emit too much heat as this can damage the young leaves. Once the seedling leaves (cotyledons) emerge the seedling will begin photosynthesis and nutrients will be absorbed by the roots.
- **Fertilization -** In most cases, a universal seedling nutrient formula is sufficient for microgreen production. Allow the liquid to drain after the nutrients are used, ensuring the growing area has enough water around the roots.

Common Microgreen Problems and How to Fix Them?

While hydroponic systems do manage to reduce some of the diseases that underground plants experience, they do come with their own set of drawbacks. One of the main problems microgreens faces is rot and disease caused by overwatering or high humidity. Too much moisture or an environment with too much humidity encourages the growth of bacteria and plant diseases. The solution is simple; for example, using a portable fan to create some air movement can go a long way toward removing moisture from the air. Another common problem with microgreens is that they can stretch and curl downward. This is a problem because it makes harvesting difficult. When the crop is nearing maximum yield, the easiest solution is time and attention. Instead, look for seeds that have been grown to be on the short side.

Hydroponic Grow Mediums for Growing Microgreens

Hydroponics is the use of water to grow plants without soil. The easiest way to grow microgreens hydroponically is to use a growing medium instead of soil (Figure 3). This medium will do something for the roots and root hairs to hold onto so the plant can stand on its own and grow well. Some crops, such as pea microgreens, can be grown directly on the grid because they are so strong that they can be transplanted easily. Generally speaking, most microgreens will grow quickly and vigorously when given the right growing medium. The aim is to aid germination by retaining water and providing a good rooting surface.

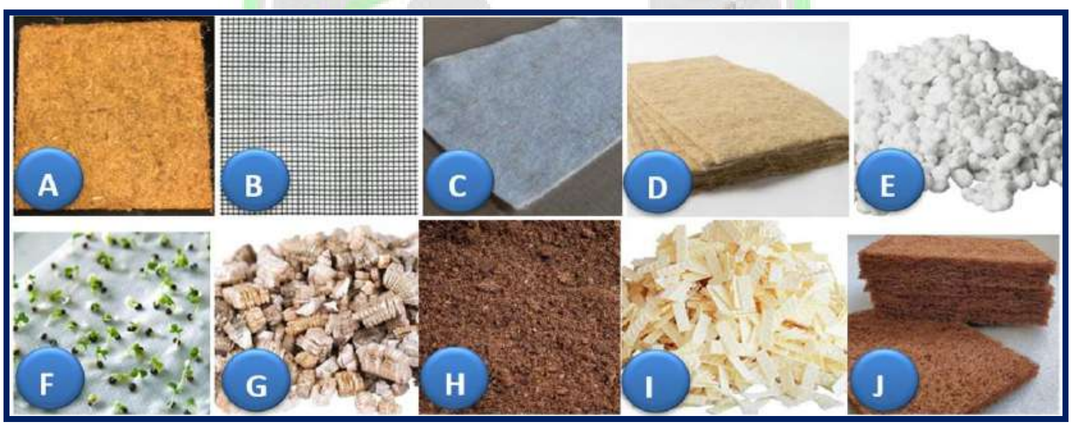


Figure 3. Hydroponic Growing media (A- coco-coir, B- mesh-screen, C- biostrate, D- hemp, E-perlite, F-paper towel, G- vermiculite, H- peat moss, I- micro-mat, J-coco-mat

- **Coco-Coir:** Coir is a hydroponic medium made from ground coconut shells with a soil-like texture. Coir is low in nutrients except potassium and sodium. Coir usually comes in the form of super-compressed 10-pound bricks that you add water to, which causes the coconut to expand and turn into a growing medium.
- **Mesh Screen:** The advantage of growing mesh microgreens is that they are a medium that can be cleaned and reused over time. This is very appealing to growers because you

save money on growing media in the long run.

- **Biostrate:** A blend of biopolymers and natural fibers designed to retain moisture for growth in a variety of hydroponic systems. Biostrate came out on top with the best germination rate, growth rate, and harvest weight.
- **Hemp:** Hemp media is made up of only loosely woven hemp fibers, this type of media is good at retaining water, so you have to be careful not to overwater or you will have problems with germination and mold. Biostrate and Hemp come in large rolls that you can cut yourself.
- **Perlite:** Perlite looks like a small rock, but it is a naturally occurring amorphous volcanic glass that has the unusual property of expanding when heated enough.
- **Paper towels:** The main advantage of tissue paper as a growing medium is that they are cheap and you can buy them almost anywhere. However, they do have some disadvantages. First, they dry out easily depending on how well they retain water (which varies from species to species), you also have to be careful not to overwater or you will have water retention due to bad air and odor.
- **Vermiculite:** Vermiculite is a naturally occurring hydrated magnesium-ferroaluminosilicate mineral that is heated in a furnace and expanded into an accordion shape. Vermiculite also falls into the recycling category because you can clean and sterilize it.
- **Peat Moss:** Made from the dead fibrous material that forms when moss and other materials decompose in peat, peat moss takes thousands of years to form. However, it is a growing medium and one of the benefits of peat moss is that it is a sterile medium.
- **Micro mats vs Confetti:** Micro Pads and Confetti are the same, except the pad version is the expanded version while the Confetti is the crushed version of the pad.
- **Coco Mat:** The coco grow mat is made of thick woven coconut fiber that creates a hydroponic growing medium. It is a good medium, but you just want it to do better.

Food safety and hygiene

As you might expect, there are food safety regulations for microgreens production. Generally speaking, good seeds used in a clean system with the right temperature and humidity levels will germinate well with few problems. However, especially in conditions of humid weather and high microgreen growth rates, many fungal diseases can develop and grow in germinated seeds. Overwatering is also a risk because the seeds will rot before they germinate. Water supply must be good, as water can carry plant diseases that affect people and crops, but municipal water supplies are usually sufficient to meet the needs of all but the most sensitive crops. This is where managing a hydroponic container farm differs from strictly controlling water and temperature. With the current focus on food safety and legislation, all growers need to understand the rules they must follow for fresh salad crops; check with your state and local authority.

Conclusion

Growing microgreens hydroponically is a smart, sustainable and profitable way to grow these plants. Hydroponics has many advantages that traditional soil growing methods cannot match. They are also versatile enough to be equally successful in all urban hydroponic farms, from low-cost, low-tech (like the water tank in your kitchen window) to high-tech. Growing microgreens in indoor, vertical farms, such as shipping containers, can provide many benefits to local communities, both in terms of food security and access to nutritious, wholesome foods. If we are to meet the needs of the growing world population by 2050, hydroponic farming of microgreens and other plants is essential, especially in urban areas where food deserts are very expensive.

Volume: 04 Issue No: 12

BLOCK CHAIN TECHNOLOGY- A GAME CHANGER FOR INDIAN FARMING

Article ID: AG-VO4-I12-09

***Poka Malini[1] and Ashish Anand[1]**

[1]Department of Agricultural Extension Education,

College of Agriculture, OUAT, Bhubaneswar, Odisha, India

*Corresponding Author Email ID: malinipoka71966@gmail.com

Abstract

Due to rapid changes in environment and population in our country there is need to switch from traditional practices of agriculture to modern technology to meet up the requirements of people. ICT helps farmers in many ways such as providing real time data on weather, market prices and crop management. Block chain technology is one of its type with decentralized information in it acting as a digital ledger. It is an advanced database storing data in blocks within chain helps in better supply chain management, avoid risks of frauds in food industry, sends weather based information, ensures food safety and manages agriculture finance. The main challenges of this technology is inaccurate data from untrustworthy data providers and expensive food traceability. Block chain technology can surely create a complimentary space in future by making life simple and safe with the information stored in it. This can be connected with other IOTs for better usage in Indian agriculture.

Keywords: Block chain Technology, Agriculture**,** Traceability

Introduction

Due to rapid changes in environment and population in our country there is need to switch from traditional practices of agriculture to modern technology to meet up the requirements of people. For improvement of productivity and sustainability in agriculture, timely and upto date information is required. Usage of ICT helps in increasing the effectiveness and efficiency of data collection, storage, analyzing agriculture data.(Walter et al,2017).This ICT helps agriculture workers and farming community to take better decisions by receiving upto date information(Kaddu and Haumba,2004). Due to this importance, various techniques were developed for the betterment of farmers. Block chain technology is one of its type with decentralized information in it acting as a digital ledger.

Content

Block chain Technology is the database in advanced form to store the data in blocks form within a chain and shares it in a transparent and secure manner. It helps in cost reduction to transfer information from with-in the farm to out of farm. Still today agriculture is a type of industry which has less digitalized sectors in world because of the problem of not able to generalize on farm data to off the farm and lack of proper analyzation. With the help of Block chain technology we will be able to know the source of our food which will be a game changer for our country's future agriculture. Some of the examples like companies like Nestle and Carrefour along with IBM used block chain for tracking Mousline, popular mashed potato brand supply chain for better transparency and traceability. An organization named AgUnity is helping millions of smallholder farmers to beat back poverty by providing digital tools like block chain to bridge gap between farmers and customers.

Block Chain Technology in Agriculture

1. This helps in improving the crop and food production by generating data from IOTs, editing the data collected, creating more data insight and saving data in the form of Block chains.
2. It also helps to deal with weather crisis be sending vital information from weather station to block chain so that farmers can take preventive measures and subsidies can be applied rapidly.
3. When IOT is combined with Block chain, it can transform food processing industry from producers to distributors.
4. It also helps in controlling frauds around the food industry who cheat others with inaccurate labels by providing traceability of product.
5. It helps farmers to get better price fastly for their product by reducing the transaction cost as they can directly contact their customers using different payment options.

Main Challenges in use of Block chain technology in agriculture

- Accurate data need to be provided by trustworthy data providers otherwise it can control food frauds. So, all the data need to examined carefully before storing it.

- Expensive food traceability schemes without much profit due to marginalization of hotels and supermarkets.

Future prospects

As this Block chain technology is a digital ledger containing decentralized information which can be used by organizations, non- profit organizations, hospitals to tackle problems of farming community globally. The block chain data is static and time stamped which cant be changed in any case. The non involvement of agents in this system helps in building direct contact of farmers with customers so that farmers can get better income, less expenditure, more flexibility in the supply chain. Farmers can also export their produce globally through this block chain enabled platform and create their mark. There is also chance for farmers to trade using crypto currency. It enables farmers to keep any eye on various environmental factors of their field like temperature, humidity etc. This helps in better data management which is reliable to get quality services to helpless farmers.

Conclusion

Block chain technology can surely create a complimentary space in future by making life simple and safe with the information stored in it. Even after having various benefits, it should be maintained carefully by accurate data from reliable data providers. This can be connected with other IOTs for better usage in Indian agriculture.

References

Kaddu, S., and Haumba, E. N. (2016). "Promoting ICT based agricultural knowledge management for increased production by smallholder rural farmers in Uganda: a case of Communication and Information Technology for Agriculture and Rural Development (CITARD), Butaleja," in Proceedings of the 22nd Standing Conference of Eastern, Central and Southern Africa Library and Information Associations (SCECSAL XXII), Butaleja, 243–252.

Kogure, J. Kamakura, K. Shima, T. Kubo, T. 2017. Blockchain technology for next generation ICT. *Fujitsu Scientific and Technical Journal*, 53(5):56-61.

Kumar, M.S.., Maheswari, V., Prabhu, J. Prasanna, M. and Jothikumar, R. 2021. Applying Blockchain in Agriculture: A Study on Blockchain Technology, Benefits and Challenges. Deep Learning and Edge Computing Solutions for High Performance Computing (pp.167-181).

Walter, A., Finger, R., Huber, R., and Buchmann, N. (2017). Opinion: smart farming is key to developing sustainable agriculture. Proc. Natl. Acad. Sci. U. S. A. 114, 6148–6150. doi: 10.1073/pnas.1707462114.

Volume: 04 Issue No: 12

ENTREPRENEURSHIP AND ORGANIC FARMING - PROSPECTS AND PROBLEM

Article ID: AG-V04-I12-10

***Dr.S. Ebenezer**

Assistant professor in commerce, Sarah Tucker College,

Tirnelveli-07, Tamil Nadu, India

*Corresponding Author Email ID: eben1441@gmail.com

Introduction

It is a well-known fact that the use of organic or biological inputs has assumed importance in the promotion of organic agriculture. In conventional agriculture where the application of chemical inputs is widely known for its direct action to feed and protect the crop, on the contrary, in organic agriculture, inputs are being used to feed the soil and to create an environment to keep the pests below the economical threshold limit (ETL). In this effort, there are two crucial issues for farmers who are in the mindset of transitioning to organic. One is the availability of organic inputs and the other one is the quality of the product.

OBJECTIVES OF THE STUDY

- To trace the historical perspective of organic farming and to highlight the methodsadopted in organic farming.
- To study the socio- economic structure of organic farmers and to know the sources ofawareness among organic farmers.
- To analyses the motivating factors to adopt organic farming system in the sampledistrict.
- To identify the problems faced by the farmers in the adoption of organic farming andto offer suitable suggestions for improvement.
- To analyze the economic benefits of organic farming compared to conventional farming.

NEED OF THE STUDY

Organic farming was practiced in India since time immemorial. The great Indian civilization mainly thrived on organic farming and it was one of the reasons that made most prosperous, till the British brought it under their control. In traditional India, the entire agriculture was practiced using organic techniques, where the fertilizers, pesticides, and the like were obtained from plant and animal products. During the dawn of Indian independence, the ever increasing population and a series of natural calamities such as flood and famine led to a severe food scarcity in India. As a result, the government was forced to import food grains from foreign countries. In order to make the country self sufficient in food production, the government had to drastically introduce various policies and measures.

PERIOD OF THE STUDY

The period of the study ranging from Nov 2024.

AREA OF THE STUDY

The historically renounced area of Tirunelveli City had been selected as the area of the study.

RESEARCH DESIGN

The researcher has been selected on Convenience sampling technique and the total numberof sample was 100.

TOOLS FOR ANALYSIS

Percentage analysis, Weighted average.

METHODOLOGY

This section describes the methodology which includes collection of data, construction of questionnaire and frame work of analysis.

COLLECTION OF DATA

The primary data have been collected directly from the farmers who are doing organic farming through interview schedule . Secondary data have been collected from standard books, articles, magazines, encyclopedia and internet.

Primary data

The study mainly based upon the primary data. Interview schedule method is usedto collect the data from the respondents. Sample size of “100” respondents have been appended in the research report.

Secondary data

The substantiate and to support the primary data required particular have been gathered by referring the reputed journals, magazines, standard news paper and book. Some of the information has been gathered from authorized web source.

LIMITATION OF THE STUDY

The studies mainly based on the data given by the respondents which may not be percent correct besides some of the other limitations are:

1. The sample of study is drawn from organic farming Tirunelveli area only.
2. The study is limited to the 100 respondents in Tirunelveli area only.

The researcher work has not covered all organic farmers of the area.

REVIEW OF LITERATURE

Introduction

This chapter will explore current literature and provide an overview of theoretical research to evaluate the aim of this study and establish fundamental background knowledge to compose research objectives. The research will delve into literature based on the acceptance and adoption ofnew technologies, more specifically Organic Farming.

K.V Rao (2013)[1] stated that excess use of chemical fertilizers has made the soil infertile in many areas. It is time for the farmers to look at organic way of farming.

Ramalakshmi S (2013)[2], opined that the adverse effect caused by chemical fertilizers on soil health has led to a new thinking of growing crops in an organic way. This means growing of crops without the use of chemical fertilizers and synthetic pesticides. This is possible by mobilizing the organic source that contains plant nutrients, processing and applying them to soil.

Using bio fertilizers

S.no	**Using bio fertilizers**	**No. Of respondents**	**Percentage (%)**
1	Restore the fertility of the soil	40	40
2	Water holding capacity of thesoil	22	22
3	Essential nutrients	18	18
4	Vitamin and proteins to the soil	20	20
	Total	**100**	**100**

Source: primary data

Interpretation:

From the above table 4.8 shows that, 40 percent of the respondents are using bio fertilizer for restore the fertility of the soil, 22 percent of the respondents are using bio fertilizer for Water holding capacity of the soil, 18 percent of the respondents are using bio fertilizer for Essential nutrients, and 20 percent of the respondents are using bio fertilizer for Vitamin and proteins to the soil. Hence it can be concluded that majority of the respondents are using bio fertilizer for restore the fertility of the soil.

Benefits from using bio fertilizer

S.No	Benefits from using bio fertilizer	No. Of respondents	Percentage (%)
1	Increase crop yield by 20-30%.	40	40
2	Replace chemical nitrogen and phosphorus by 25%.	22	22
3	Activate the soil biologically	18	18
4	Restore natural soil fertility	20	20
	Total	**100**	**100**

Source: primary data

Interpretation:

From the above table 4.9 shows that, 40 percent of the respondents felt that using bio fertilizer Increases crop yield by 20-30%, 22 percent of the respondents felt that using bio fertilizer Replacechemical nitrogen and phosphorus by 25%. , 18 percent of the respondents felt that using bio fertilizer activate the soil biologically, and 20 percent of the respondents felt that bio fertilizer benefits from Restore natural soil fertility. Hence it can be concluded that majority of the respondents felt that using bio fertilizer Increases crop yield by 20-30%

Advantages of bio fertilizer

S.no	Advantages of bio fertilizer	No. Of respondents	Percentage (%)
1	Cost effective.	22	22
2	Supplement to fertilizers	20	20
3	Eco-friendly (Friendly withnature)	40	40

4	Reduces the costs towards fertilizers use, especially regarding nitrogen and phosphorus	18	18
	Total	**100**	**100**

Source: primary data

Interpretation:

From the above table 4.10 shows that, 22 percent of the respondents are says advantages of bio fertilizer is cost effective, 20 percent of the respondents are says advantages of bio fertilizer is Supplement to fertilizers, 40 percent of the respondents are says advantages of bio fertilizer is Eco- friendly (Friendly with nature), and 18 percent of the respondents are says advantages of bio fertilizer is Reduces the costs towards fertilizers use, especially regarding nitrogen and phosphorus. Hence it can be concluded that majority of the respondents are says advantages of bio fertilizer is Eco-friendly (Friendly with nature).

Problems faced by the farmers in the adoption of organic farming system

Problems faced by the farmers in adoption of organic farming	**Weighted average**	**Rank**
Lack of awareness aboutorganic products	**16.8**	**I**
Low demand due to highprice	**16.18**	**II**
Lack of incentives fromGovernment	**15.86**	**III**
Non availability of skilledlabours	**15.46**	**IV**
Lack of Technical knowledge	**14.92**	**V**
Short supply of quality seeds	**11.98**	**VI**
Difficulty in preparingorganic pesticides	**9.92**	**VII**

Major challenges of organic farming

S.no	**Major challenges of organic farming**	**No. Of respondents**	**Percentage (%)**
1	**Lack of awareness**	38	38
2	**Marketing and Prices**	30	30
3	**Shortage of biomass in soil**	22	22

4	**High Cost and unavailability of inputs**	10	10
	Total	**100**	**100**

Source: primary data

Interpretation:

From the above table 4.17 shows that, 38 percent of the respondents Major challenges of organicfarming is lack of awareness**,** 30 percent of the respondents Major challenges of organic farming

FINDINGS, CONCLUSION AND SUGGESTION

FINDINGS:

1. 60% of the respondents are male; 38%belongs to the age-group 40-50; 60% of the respondents are illiterate; 58% of the respondents area of residence is rural; 72% of the respondents are married; 50% of the respondents family income 20,000-30,000; 48% respondents farming experience in above 15 years; 40% of the respondents are using bio fertilizer; 40% of the respondents are benefited by using bio fertilizer; 40% of the respondents are says advantages of bio fertilizer is cost effective; 60% of the respondents Share of the income from fruits and vegetables in your house holdincome; 52% of the respondents are using organic fertilizer; 38% of the respondents preserve soil fertility of fertilization; The weighted average value 4.14 shows that the most of the respondent saying in Fullyaware. Fully aware got first place; The weighted average value 4.15 shows that the most of the respondent saying in strongly agree. Strongly agree got first place; The weighted average value 4.16 shows that the most of the respondent saying in stronglyagree. Strongly agree got first place; 38% of the respondents' Major challenges of organic farming is lack of awareness; 42% of the respondents Methods for plant protection are used Physical pheromone andtraps; 38% of the respondents sell their products to wholesalers.

SUGGESTIONS:

Due to the continuous application of petroleum products for four/ova decades as fertilizers, pesticides and weed killers, soil changed into the impotent condition and the productivity is far below compared to other several countries. Soil testing is to be done whenever required to apply required organic manure. Farmers are required to take the initiative and take required steps to bring back the soil to the original condition as it was found prior to Green

Revolution. Application of chemical pesticides and weed killers are to be minimized or banned, since they killed those pests/insects/birds which are friendly one to farmers. Natural pesticides are to be prepared for development and growth. Necessary guidelines for using organic pesticides and control of diseases are to be expanded. Water plays key role in the farming especially in organic farming. Water should be contamination-free and testin facilities are to be added. Water being a scarce commodity especially in Tamil Nadu for irrigation, modern techniques of drip, sprinkler water irrigation system should be implemented allocating with a massive investment in priority. Mulching technique is to be popularized to minimize water consumption harvesting rain water, efficient usage of underground water is to be streamlined to strengthen the cultivation in periods of monsoon failure.

Farmers are required to learn all organic farming practices especially in the preparation of organic manures, organic pesticides, insect, mulching techniques and followintegrated farming practices. It is requested to seek crop insurance deönitely for certain risk factors in the cultivation without hesitation to avoid heavy loss. It is suggested to seek crop insurance for certain known risk in cultivation. It helps protect the health of the world by reducing emissions. The reduction of the residue level in the substance decreases human and animal health risks. It contributes to sustaining sustainable agricultural production. It lowers farm production costs and increases the health of soils. It ensures that natural resources are used optimally for the short term and conserve for future generations. It saves animals and machines resources and reduces the chance of crop failure.

Conclusion

Organic production is a specific production method preserving environment and providing healthy food of high quality having the following advantages: production of healthy food with high technological characteristics; increasing demand; new markets; higher prices; less intensive use of land; lower energy consumption; environmental protection; rural development, etc. Organic farming is an overall systematic approach based on a number of processes leading to sustainable development. Increasing employment and decreasing unemployment, reducing the risk of poverty, increasing the attractiveness of some regions or destinations as a result of improvement of ecological conditions of life, attracting direct foreign investments, increasing incomes and employment in rural regions.

References

1) Ashrufun Ness and Debbie Bartlett, “A comparison of organic farming in the UK andBangladesh”, Green FarmingVol.2, No. 3, pp. 294-297,2011.

2) B a b a l a d , H . B . “ P r i n c i p l e s a n d P r a c t i c e s o f O r g a n i c Fa r m i n g ”, I nL.V.Hirevenkanagoudar et al (Eds.), Extension Strategies for Promotion of Organic Farming, Agro tech Publishing Academy, Udaipur, pp. 63-75, 2007.

3) Bheemappa, A. “Srep Approach for Promoting Organic farming”, In L.V. Hirevenkanagoudar et al (Eds.), Extension Strategies for Promotion of Organic Farming, Agrotech Publishing Academy, Udaipur, pp. 285-286, 2007

4) Cathy Farnsworth and Jessics Hutchings, “Organic Agriculture and Womens Empowerment”, IFOAM Germany, Retrieved from http://dnb.ddb.de, ISBN 13: 978-3-940946-15-7, 2009.

Volume: 04 Issue No: 12

GREEN REVOLUTION 2.0

Article ID: AG-VO4-I12-11

Yogavasantham K [1] and Paul Mansingh J [2*]
Department of Agricultural Extension & Economics
[1,2] VIT School of Agricultural Innovations and Advanced Learning (VAIAL)
Vellore Institute of Technology.
*Corresponding Author Email ID: paul.mansingh@vit.ac.in

Introduction

"Food is medicine; Medicine is food." Is this statement becoming a lie? It will soon be a nanny's tale if the current agricultural scenario continues to be the same. Food is the first and foremost secure need of humanity, but due to the adverse use of chemical inputs it is becoming a threat for humanity. According to WHO, "pesticides are potentially toxic to humans and can have both acute and chronic health effects depending on the quantity and ways in which a person is exposed". In a country like India, where indiscriminate use of pesticides is done by most of the farmers, this statement is alarming! "More and more pesticides are being sprayed worldwide with deadly consequences for humans and nature," a report finds.

Unsurprisingly a research states that globally 150 million tons of nitrogen is applied to crops every year and only 35 percent of this is used by crops, meaning 75 million tonnes of Nitrogen runs into water bodies and natural environment (Ritchie, 2021). Almost two-thirds of the applied nitrogen acts as environmental pollutant. India accounts for about one-fifth of the nitrogen and phosphorus pollution. This is not just the case of Nitrogen, sadly the same scenario takes place with almost every agrochemical that's used. Fertilizers are pollutive in nature not only when they are used but also in their manufacturing method. The second largest used fertilizer ammonia takes lot of energy to make of which comes from burning fossil fuels like coal, ,methane etc. Ammonia manufacturing alone contributes about 1 to 2 percent of the worldwide carbon dioxide emission and the list doesn't end with Ammonia alone. So now a question arises, is this really necessary? Can't humanity survive without any agrochemicals? The answer is no! Humanity can survive without any Agrochemicals and the solution lies in our hand. It lies within us. It lies in our nature. Yes, natural farming is the only solution to India and the world need **Green revolution 2.0 – A real Green revolution!**

Tracing the past of our country, before 1960s, the only way of farming practiced was organic farming without any use of chemical fertilizers or pesticides. (International Panaacea Limited Biologicals,2022) A common saying in the Cauvery Delta was that "the space in which an elephant could lie down produced enough food to feed 7 people" indicating organic farming did not produce lower yields. What happened after the 1960s has resulted in today's scenario of lower yields in organic farming.

The green "red" revolution

In 1966 to 67 the green revolution was introduced in India through Punjab as a part of development program supported by International Donor Agencies and Government of India (GOI). During British raj, India's grain economy depended heavily on a one-sided exploitative relationship because of the famines during 1964-65 and 1965-66 causing huge shortage for food grains, which introduced the use of high yielding variety seeds, fertilizers and pesticides. Due to this, there was a hike in the cost of cultivation where marginal farmers could not get proper financing and got into debt traps and were forced to work as farm labourers in landlords land. This high cost of cultivation pushed and is pushing even now the farmers to get out of the agricultural sector and this led to today's ultimate labour shortage. As agriculturalists were driven out of their profession, farming became a low-income sector. By then, a remarkable 70 percent of the nation's food grains hailed from Punjab, which unfortunately also witnessed a surge in farmer suicides, increasing by 51.97 percent. (Dutta, 2012). Thus, the green revolution was tinged grey.

While there are a lot of studies and articles stating the dark Side of green revolution, now is the time to debate about how we are going to overcome its effects and make the country greener.

India 2024 and its needs

The union budget of 2024-25 announced the push towards natural farming in 2 years where 1 crore farmers will be initiated into natural farming with support of certification and branding. (Ministry of Agriculture and Farmers Welfare,2023). While the country is talking about natural farming there is a grey area where many farmers or most of the farmers have not even thought about their conversion to organic way of farming. So, converting them to natural farming will be a big task for the country. While natural and organic farming remains the best option for the entire world to keep the earth alive and healthy, the biggest issue to address in a growing country like India is its population. Whenever there is a talk about organic or natural farming in India the very first concern that arises is food security to feed this population. While organic farming is the best option but natural or organic farming has a threshold level of yield which is the natural limit. According to Masanobu Fukuoka (Father of Natural farming) in his book Natural Way of Farming, any level of yield achieved higher than this is abnormal and will definitely lead to ill effects in the long run. Crossing nature's border would definitely lead to its destruction, so any practice or technology or technique taken into account that increases the natural yield limit would lead to other problems like pest or disease outbreak or environmental damage. Considering all this in mind, the yield obtained from chemical farming cannot be obtained through natural or organic farming. This has to be understood by everyone.

But, within the next few years, if the entire farming population does not convert to organic or natural farming, the world has to face its consequences. While analyzing both present and future needs of the country, to make a sustainable decision the only possible and toughest way is to increase the population of farming community to meet out the food security needs of the nation. The farming community has to be enlarged. In this era, where the world focuses on the developing modern technology to take man away from soil to skyscrapers, but the only way is to bring them back to the soil. This one may seem very controversial. but to heal earth and nature, for mankind to survive, a decision has to be made. The government should definitely consider making the youth of the country to get involved in farming. Policies should be made to improve the primary and secondary sectors, to improve processing industries. Home or kitchen gardens should be highly promoted to reach certain level of self-sustainability among the families of urban areas.

While every organization including the government is promoting farmers to do natural farming, for a second green revolution, let's dive into the challenges faced in the process.

Challenges in conversion and practice of organic farming and natural farming

1. The very first question is, why is there a lack of subsidies for organic inputs and a huge subsidy for chemical inputs? Certain chemical inputs like urea which is used by a farmer

for almost every crop are available at lower cost and produce higher yields, so a farmer would naturally opt for it. As organic farming has lower return on investment in the beginning years, it's tough for a farmer to cope up. So, during the beginning of the conversion period government should think of framing policies for financial assistance.

2. **Lack of proper guidance**: Even though technology is in its booming era, there is still a huge gap in the technology transfer to farmers. A farmer has to know about the proper organic crop protection management practices to do organic farming, while the web has a bunch of random practices. Precise information should reach a farmer, to help this the government or NGOs could try running consultancies for organic and natural farmers to provide them proper guidance on organic and natural farming practices. A wing specialized in organic and natural farming practices should formulate precise practices and work for farmers' welfare. Mentorship could also be provided, for a certain number of farmers, a mentor can be assigned and personalized recommendations can be given to the farmer.
3. **Lack of proper marketing support:** In India, most of the organic farmers don't market their produce, they mostly follow subsistence farming. If the government can make organic produce fetch higher price in the market, these subsistence farmers could be converted into commercial farmers. Federations like Aavin (for milk) can be formulated for organic produce where organic produce can be aggregated from small farmers and marketed, which provides the farmers a better take on price for their produce.
4. **Lack of input channels**: "Organic inputs are hard to find, I want to do organic farming, but I could not get Farm Yard Manure in huge quantity as per the recommendation" a farmer from Vellore district of Tamil Nadu says. Locating organic inputs is a huge obstacle for an organic farmer when he wants to do organic farming in a large scale. This is a practical field level issue on which the government should really give a thought about.

Conclusion

While these remain the major issues or problems that need to be addressed, there are several day to day or ground level problems that remains unnoticed. If only we could analyze and address all these issues, we can expect the farming population to undergo a 2nd green revolution, but this time without the grey tinge. Let's make India greener again!

References

Dutta, S. (2012). Green Revolution Revisited: The Contemporary Agrarian Situation in Punjab, India. *Social Change*, *42*(2), 229–247. https://doi.org/10.1177/004908571204200205

Hannah Ritchie (2021) - "Excess fertilizer use: which countries cause environmental damage by overapplying fertilizers?" Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/excess-fertilizer'

Ministry of Agriculture and Farmers Welfare. (28 March 2023). National Mission on Natural Farming. [Press release].https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1911558

International Panaacea Limited Biologicals. (2022, July 20). The Need of Organic Farming in India. https://iplbiologicals.com/the-need-of-organic-farming-in-india/.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

BREEDING WITH SPICATA COCONUTS: A STEP TOWARDS RESILIENT AND PRODUCTIVE PALMS

Article ID: AG-V04-I12-12

Adarsh Balachandaran, V. Sivakumar and C. Kavitha*
Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India
*Corresponding Author Email ID: ck77@tnau.ac.in

Introduction

The Spicata coconut also known as "spicate," is a special type of coconut palm (*Cocos nucifera*) that stands out for its unusual flowering pattern. The Spicata variety of coconut palm possesses unbranched, spike-like inflorescences, which features a higher number of female flowers in contrast to the majority of coconut palms that produce branched flower clusters. The name "spicata" came from the Latin word "spicatus," which means spiky or pointed. Spicata coconuts are easier to handle since they are usually dwarf or semi-dwarf. They are renowned for being suitable for small-scale agriculture and having a reasonable level of yield. Native to tropical regions, Spicata coconuts thrive in coastal and humid climates, offering resilience against certain environmental stresses. This variety is not just valued for its unique morphology but also for its practical applications in agriculture, landscaping and coconut breeding programs (Perera et al., 2008).

Uses of Spicata Coconut

Spicata coconuts serve a variety of purposes, ranging from agricultural to ornamental:

1. Agricultural Value

Nut Production: While they produce slightly fewer nuts than traditional varieties, Spicata coconuts are prized for their moderate yield and stable growth patterns. The nuts are used for water, oil, and copra production.

Ease of Harvest: Their dwarf or semi-dwarf nature makes them easier to harvest, reducing labour and costs.

2. Ornamental Use:

The unbranched inflorescences of the Spicata variety make it visually distinct, enhancing its appeal for landscaping and decorative purposes. These palms are often planted in gardens, parks, and resorts for their aesthetic value.

3. Environmental Benefits:

Spicata trees play a role in soil conservation, coastal protection, and carbon sequestration. Their ability to grow in challenging conditions makes them valuable for reforestation and ecological restoration projects.

4. Role in Coconut Breeding:

Studies reveal that spicata coconuts possess a normal chromosome complement (2n=32) alongside aneuploid variations, suggesting genetic diversity that can be harnessed in breeding. Its unique genetic traits, including its spike-like inflorescence and semi-dwarf stature, make it a valuable candidate for hybridization. Research indicates significant genetic variability among coconut accessions, which is essential for breeding programs aimed at improving traits such as fruit size and yield, pest resistance and adaptability to various climates (Sobral et al., 2019).

Spicata coconuts are often crossed with other varieties to develop hybrids with desirable traits such as:

- *Higher Yield:* Combining Spicata's traits with high-yield varieties enhances productivity.
- *Disease Resistance:* Crossbreeding helps to develop palms that are more resistant to common coconut diseases, such as lethal yellowing.
- *Dwarf Size:* Incorporating Spicata genetics into breeding programs promotes the development of dwarf or semi-dwarf hybrids, which are easier to cultivate and harvest.

Breeding Strategies

Conventional and Biotechnological Approaches: Current breeding programs are integrating traditional methods with modern biotechnologies, such as molecular markers and *in vitro* culture techniques, to enhance genetic improvement in coconuts (Bandupriya et al., 2020).

International Collaboration: There is a call for global cooperation to audit and enhance breeding programs, ensuring adequate funding and resource allocation (Bandupriya et al., 2020).

Importance of Spicata Coconut in Breeding

1. Preserving Genetic Diversity

Spicata coconuts contribute to the genetic pool of coconuts, offering unique traits that are invaluable for maintaining biodiversity. By incorporating these traits into breeding programs, researchers ensure the sustainability of coconut cultivation worldwide.

2. Addressing Agricultural Challenges

As coconut farmers face increasing challenges such as climate change, pests, and diseases, the Spicata variety provides a foundation for developing resilient coconut trees. Hybrids derived from Spicata coconuts are better equipped to withstand harsh conditions and sustain yields in the face of adversity.

3. Economic and Environmental Impact

Through breeding programs, Spicata coconuts help improve the livelihoods of farmers by reducing labour and increasing productivity. Additionally, the environmental benefits of planting resilient hybrids extend to soil protection, water conservation, and carbon sequestration.

Spicata Coconut: A Future in Sustainable Cultivation

The Spicata coconut's unique traits and versatility make it an integral part of modern coconut farming and breeding. By assisting farmers in producing robust and fruitful crops, its application in hybrid creation responds to the rising demand for sustainable agriculture. Beyond its advantages in agriculture, the Spicata coconut's aesthetic and environmental contributions guarantee its continued relevance in the global effort to achieve a balance between ecological preservation and economic growth. Researchers and farmers alike are laying the groundwork for a more resilient and sustainable future for coconut agriculture by funding the research and production of Spicata coconuts.

References

Perera, P. I. P., Wickremasinghe, I. P., & Fernando, W. M. U. (2008). Morphological, cytogenetic and genotypic differences between spicata and ordinary tall coconut (Cocos nucifera L.). *Journal of the National Science Foundation of Sri Lanka*, *36*(1), 103-108. https://doi.org/10.4038/jnsfsr.v36i1.138

Bandupriya, H. D., Perera, C., Pereira, M. G., & Bourdeix, R. (2020). Towards innovative coconut breeding programs. *Coconut Biotechnology: Towards the Sustainability of the 'Tree of Life'*, 241-272. https://doi.org/10.1007/978-3-030-44988-9_12

Sobral, K. M. B., de Queiroz, M. A., Neto, I. D. S. L., de Oliveira, R. S., & Ramos, S. R. R. (2019). Há variabilide genética em acessos de coqueiro-anão conservados no Brasil?. *Revista Caatinga*, *32*(1), 52-61. https://doi.org/10.1590/1983-21252019v32n106rc

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

A SUSTAINABLE ENVIRONMENTAL APPROACH FOR SODIC SOILS

Article ID: AG-V04-I12-13

***T. Sherene Jenita Rajammal, M. Baskar and P. Vaishnavi**

Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

*Corresponding Author Email ID: shereneraj@yahoo.co.in

Introduction

One of the most promising issues facing in the 21st century was soil degradation. Out of 147 million hectares of degraded land, 23 million hectares were impacted by alkalinity (sodicity). These problems have posed serious threats to agricultural productivity and sustainable land use, underscoring the need for effective soil management and reclamation strategies. The Indian Council of Agricultural Research-Central Soil Salinity and Research Institute in Karnal, along with several State Agricultural Universities, has focused on developing effective reclamation technologies to address these soil sodicity. The reclamation technologies available are gypsum application, implementing sub-surface drainage systems, cultivating salt-tolerant crop varieties. These initiatives aim to restore soil health and enhance agricultural productivity in sodic soil areas.

Alkali / Sodic soils

Sodic soils are characterized by higher levels of exchangeable sodium compared to calcium and magnesium, with sodium carbonate (Na_2CO_3) and sodium bicarbonate ($NaHCO_3$) being the main salts present. These soils generally exhibit a higher Sodium Adsorption Ratio (SAR) greater than 13 and an Exchangeable Sodium Percentage (ESP) >15. Their pH typically ranges from 8.5 to 10.0, while the Electrical Conductivity (EC) of the saturation extract remains below 4 dS m^{-1}. Due to the formation of Na-humic substance complexes, sodic soils often appear black and have poor permeability for both water and air (Fig. 1). This lack of permeability can significantly impact water movement and root growth, posing challenges to agricultural productivity.

Fig. 1 Sodic soil

Genesis of sodic soils

Soil colloids adsorb and retain cations on their surfaces. Cation adsorption occurs because of the electrical charges at the surface of the soil colloids. While adsorbed cations are combined chemically with the soil colloids, they may be replaced by other cations that occur in the soil solution. Calcium and magnesium are the principal cations found in the soil solution and on the exchange complex of normal soils in arid regions. When excess soluble salts accumulate in these soils, sodium frequently becomes the dominant cation in the soil solution resulting alkali or sodic soils. Albitic minerals present in rocks as parent rocks are also the major cause for sodic soil origin.

Major production constraints

Excess exchangeable sodium in alkali soils affects both the physical and chemical properties of soils. a) Dispersion of soil colloids b) Specific ion effect c) poor infiltration rate

Reclamation of alkali / sodic soils

Physical Amelioration

This is not actually removing sodium from exchange complex but improve physical condition of soil through improvement in infiltration and aeration. The commonly followed physical methods include

- ✓ Deep ploughing is adopted to break the hard pan developed at subsurface due to sodium and improving free-movement water. This also helps in improvement of aeration.
- ✓ Providing subsurface drainage is also practiced improving aeration and to remove further accumulation of salts at root zone.
- ✓ Sand filling which reduces heaviness of the soil and increases capillary movements of water

- ✓ Profile inversion – Inverting the soil benefits in improvement of physical condition of soil as that of deep ploughing.

Chemical Amelioration

Reclamation of alkali / sodic soils requires neutralization of alkalinity and replacement of most of the sodium ions from the soil – exchange complex by the more favourable calcium ions. This can be accomplished by the application of chemical amendments (the materials that directly or indirectly furnish or mobilize divalent cations, usually Ca^{2+} for the replacement of sodium from the exchange complex of the soil) followed by leaching to remove soluble salts and other reaction products. The chemical amendments can be broadly grouped as follows:

a. Direct Ca suppliers: Gypsum, calcium carbonate, phospho-gypsum, etc.

b. Indirect Ca suppliers: Elemental Sulphur, sulphuric acid, pyrites, $FeSO_4$, etc

c. Other sources

Distillery spent wash

Distillery spent wash is acidic (pH 3.8-4.2) with considerable quantity of magnesium. About 2 lakh litres of distillery spent wash can be added to an acre of sodic soil in summer months. Natural oxidation is induced for a period of six weeks with intermittent ploughing once in a month. In the second month (after 45-60 days) fresh water may be irrigated and drained. Such a treatment reduces the pH and exchangeable sodium percentage

Biological amelioration

Daincha

Dhaincha (Sesbania bispinosa), a fast-growing leguminous plant, presents a promising and sustainable solution for sodic soil reclamation. Its ability to fix atmospheric nitrogen enriches the soil while its root system enhances soil structure and reduces sodicity. Recent studies have demonstrated that dhaincha cultivation significantly lowers soil pH, improves nutrient availability, and promotes microbial diversity in sodic environments. Furthermore, incorporating dhaincha into soil management practices can lead to enhanced crop yields and improved sustainability in agricultural systems.

Crop choices

Rice is preferred crop in alkali / sodic soil as it can grow under submergence, can tolerate fair extent of ESP and can influence several microbial processes in the soil. Agroforestry systems like silviculture, silvipasture etc. can improve the physical and chemical properties of the soil along with additional return on long-term basis. Some grasses like Brachariamutica (Para grass) and Cynodondactylon (Bermuda grass) etc. has been reported to produce 50% yield at ESP level above 30. The sodicity tolerance ratings of different crops was given below

Relative tolerance of crops to sodicity

S. No	ESP (range)	Crops
1.	2-10	Deciduous fruits, nuts, citrus, avocado
2.	10-15	Safflower, black gram, peas, lentil, pigeon pea
3.	16-20	Chickpea, soybean
4.	20-25	Clover, groundnut, cowpea, pearl millet
5.	25-30	Linseed, garlic, cluster bean
6.	30-50	Oats, mustard, cotton, wheat, tomatoes
7.	50-60	Beets, barley, sesbania
8.	60-70	Rice

Relative yields are only 50% of the potential in respective sodicity ranges

Tolerance to sodicity	ESP	Tress
High	40-50	Ber, tamarind, sapota, wood apple, date palm
Medium	30-40	Pomegranate
Low	20-30	Guava, lemon, grape
Sensitive	20	Mango, jack fruit, banana

Conclusion

Managing sodic soils sustainably is essential for improving soil health, boosting agricultural productivity, and protecting ecosystems. By using soil amendments like gypsum, improving irrigation, and selecting suitable crops, sodic soils can be rehabilitated. Practices such as mulching, cover cropping, and agroforestry, along with precision agriculture, help reduce environmental impact and enhance long-term soil health. These approaches improve water use efficiency, reduce land degradation, and support climate resilience, ensuring food security and protecting natural resources. Sustainable management of sodic soils is key to a healthier environment and resilient agriculture.

Volume: 04 Issue No: 12

SMART FARMING WITH AQUAPONICS

Article ID: AG-V04-I12-14

Ninitha Nath C.*

Assistant Professor, Kerala Agricultural University, Kerala, India

*Corresponding Author Email ID: ninithanath.c@kau.in

Introduction

The growing environmental, social, and economic challenges highlight the need for innovative and sustainable solutions in food production and consumption systems. The concern about traditional agriculture's impact on land, water and resources has led to a surge in interest in sustainable farming methods. Aquaponics has emerged as a highly efficient farming solution that addresses these multiple farming challenges. By using significantly less water than conventional farming, reducing the dependence on synthetic fertilizers and minimizing waste, aquaponics offers a sustainable solution for producing food without damaging our environment.

What is Aquaponics?

Aquaponics is a sustainable farming technique that integrates two food production disciplines: 1) aquaculture, the farming of aquatic organisms and 2) hydroponics, the cultivation of plants in water without soil. It combines the two systems into a standard recirculating aquaculture system which filters and removes the organic matter that builds up in the water, keeping the water clean for the fish. In an aquaponic system, the nutrient rich effluent from fish tanks is filtered through an inert substrate containing plants (Shete *et al*., 2016). The plants act as a biological filter by removing the fish wastes and improving the quality of culture water.

The basic principle of aquaponics is to provide fish with feed of the right composition. The ammonia excreted by fish through urine and gills are then converted into nitrates via nitrification by nitroso bacteria and nitro bacteria. This nitrate rich water is then directed to the hydroponic beds where the plants function as water reprocessing units by removing the nitrates from the water for growth. The nutrient depleted water is then transferred back into the aquaculture where the cycle repeats. The amount of fish waste is influenced directly by the number and size of fish as well as the amount of feed provided., while plant nutrient requirements depend on the type of crops and its growth stage. The result is value-added products such as fish and vegetables while minimizing nutrient pollution into watersheds. Aquaponics offers several advantages such as higher yields of produce and protein, reduced land usage with potential for vertical farming, minimal weed growth, lower ongoing maintenance, significantly reduced water consumption due to its circular design and flexibility provided by movable infrastructure (Konig *et al*., 2018).

Historical background

Aquaponics is not a modern invention, its origins can be traced back to ancient civilizations. One of the earliest known examples is the Aztec chinampas, a system of stationary floating gardens established between 1150 and 1350 BC, which integrated fish farming and crop cultivation in shallow lakes. Similarly in Southeast Asia, rice paddies were stocked with fish over 1500 years ago, creating a natural aquaponic system.

The foundation of modern aquaponics was laid in the late 1970s and early 1980s when researchers started experimenting at the New Alchemy Institute North Carolina State University (USA) developed the basis of modern aquaponics. One of the most notable advancements occurred at the University of the Virgin Islands (UVI) in 1980, where a comprehensive aquaponic system was developed. Today, aquaponics is practiced worldwide, ranging from small-scale home gardens to large commercial farms continuing its evolution as a sustainable farming method (Goddek *et al*., 2015).

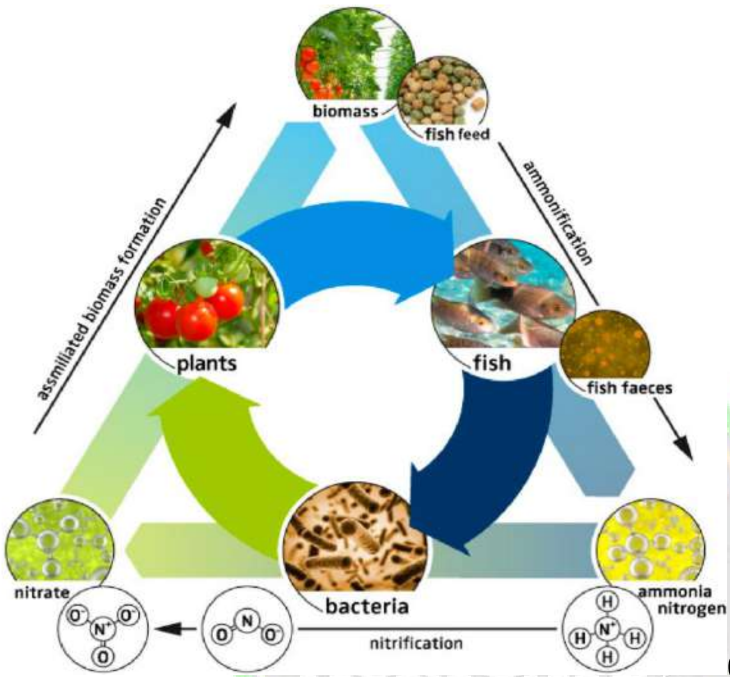
Principles of Aquaponics

The system creates a symbiotic relationship between fish, microorganisms and plants and promoting the sustainable use and recycling of water and nutrients. In this system, water recirculates in a loop as it flows from the fish tank to filtration units before pumped into the hydroponic beds that are used as water reprocessing units. The filtration units consist of mechanical filters such as drum filters or settling tanks to remove solid particles and biofilters such as trickling filters or moving bed biofilters to facilitate nitrification processes.

Components of aquaponics system

The typical components of an aquaponics systems include a fish tank, grow bed, grow bed support, sump tank, plumbing pipes and fittings, bell siphon, water pump, aerator and air stones, grow lights, heater, grow media, monitoring system and timers and controllers.

Plants : Aquaponic systems are well-suited for growing leafy greens and herbs due to their low to medium nutritional requirements. Commonly cultivated plants include lettuce (*Lactuca sativa*), spinach (*Spinacia oleracea*), mint (*Mentha spp.*), chives (*Allium schoenoprasum*), basil (*Ocimum basilicum*), and watercress (*Nasturtium officinale*).



(Goddek *et al.*, 2015)

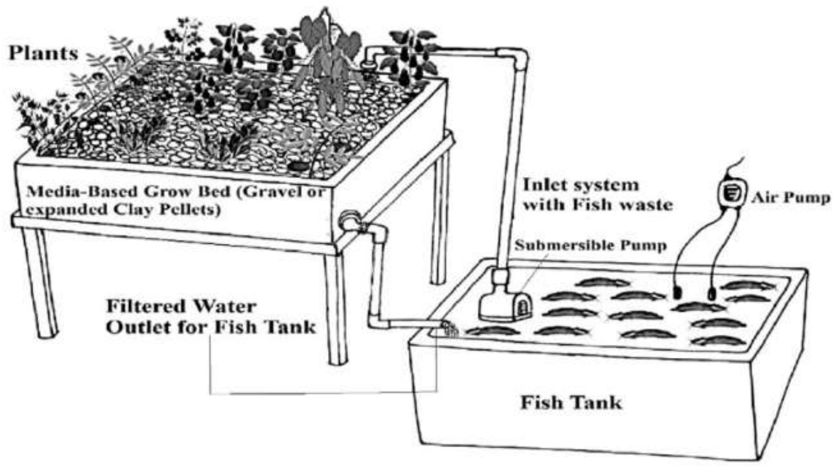
Fish species: Commonly used species include Tilapia, Trout, Perch, Bluegill, Arctic char, Largemouth bass, Koi carp, Goldfish, Murray cod, Crappies, Rainbow trout, common carp and Asian sea bass. These species are selected based on their compatibility with the plants, system design, and overall maintenance requirements. (Diver, 2006)

Types of Aquaponics systems

I. Based on hydroponic beds:

1. Meda based grow bed systems

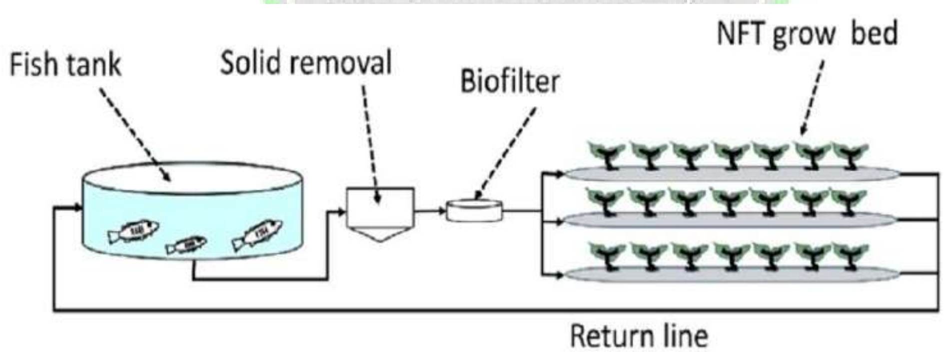
   In this, plants are gown in a bed filled with a growing medium such as gravel, clay pebbles or lava rock. The growing media not only provides support for the plants but also serves as a biofilter. Water from the fish tank is pumped through the grow bed, where it is filtered by the media before returning to the tank. Media based systems are straightforward to set up, making them an excellent choice for beginners.



(Bhanja *et al.*, 2024)

2. Nutrient film technique (NFT) bed systems

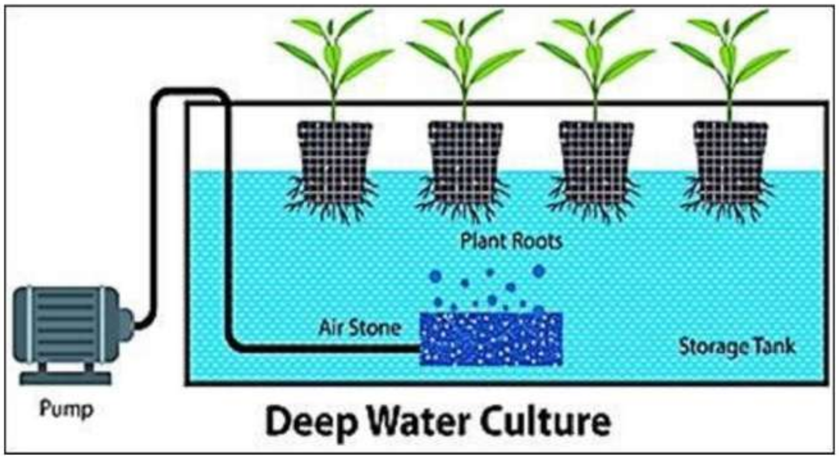
NFT systems involve growing plants in channels where a thin film of nutrient rich water flows over the roots. The water is pumped from the fish tank into the channels and then flows back into the tank. This method ensures that plant roots receive a constant supply of nutrients and oxygen. NFT systems are efficient and suitable for growing leafy greens and herbs but may require more precise monitoring of water flow and nutrient levels.



(Adhikari *et a.l*, 2020)

3. Raft system/ Deep water culture bed (DWC) system

In this system, plants are grown on floating rafts with their roots submerged directly in nutrient rich water. The water is continuously circulated between the fish tank and the plant raft, ensuring a steady supply of nutrients and oxygen. Raft systems are highly productive and can support a wide variety of plants, making them popular for both home and commercial use.



(Bhagawati *et al.*, 2020)

II. Based on farming scale: 1) small scale aquaponics, 2) low scale aquaponics and 3) micro aquaponics.(Khakyzadeh *et al.*, 2015)

III. Based on location: 1) home-based aquaponics, 2) factory-based aquaponics and 3) building- based aquaponics(Specht *et al.*, 2016)

Benefits of aquaponics

1. Water conservation: The system recycle water continuously between the fish tank and grow beds, reducing water usage significantly compared to traditional farming. Only minimal water is lost to evaporation and plant uptake.
2. Waste reduction: Fish waste is repurposed as a natural fertilizer for plants, reducing waste and creating a closed loop system that minimizes environmental impact.
3. Space efficiency: Aquaponics systems can be designed vertically, making them ideal for small spaces, such as urban environments, rooftops and balconies. This maximizes the use of limited space for food production.
4. Urban food production: Aquaponics can be implemented in various urban settings, such as rooftops, balconies and basements contributing to urban food security and reducing the carbon footprint associated with transporting food over long distances.
5. Higher productivity: Dual production of fish and plants simultaneously maximizing output from a given space. Plants in aquaponics systems often grow faster and more vigorously due to the continuous supply of nutrients from fish waste leading to higher crop yields and shorter growth cycles, allowing for more frequent harvests.

6. Organic production : The system minimizes the need for chemical pesticides, as natural pest management techniques can be used. Additionally, the nutrient rich water from the fish tank serves as a natural fertilizer for the plants, eliminating the need for synthetic fertilizers and prevents chemical runoff that can harm the environment (Zheng and Yep, 2019).

Challenges and Considerations of Aquaponics

Aquaponics, while innovative and sustainable, comes with several challenges that require careful consideration. The high initial setup costs for equipment, infrastructure, and materials can be a barrier for many, especially small-scale farmers. Managing an aquaponics system demands technical knowledge and daily monitoring to maintain water quality, nutrient balance, and overall system health. Additionally, these systems are energy-intensive, relying on pumps, aerators, and sometimes grow lights, which can increase operational costs. Balancing the specific requirements of fish and plants, such as temperature, pH, and nutrient levels, can also be complex, limiting management flexibility. Despite these challenges, aquaponics remains a promising solution for sustainable food production with proper planning and expertise.

Conclusion

Aquaponic systems hold significant potential to address several sustainability challenges in agriculture, particularly by producing high yields with minimal added nutrients and greatly reducing nutrient discharge and water loss from aquaculture. These systems benefit the farming community by providing a year-round supply of fish and vegetables while conserving water, and eliminating issues associated with soil and other challenges faced in traditional cultivation methods. With its ability to address critical issues like food security, resource conservation, and urban farming, aquaponics offers a promising pathway toward eco-friendly and efficient food production.

References

Adhikari, R., Rauniyar, S., Pokhrel, N., and Wagle, A. 2020. Nitrogen recovery via aquaponics in Nepal: current status, prospects, and challenges. *SN Appl. Sci.* 2: 2452-2996.

Bhagawati, R., Paul, S., and Dambale, A.S. 2020. farm waste management. In: *ADVANCES IN AGRONOMY* (13th Ed.). AkiNik Publications , New Delhi, pp.77-105.

Bhanja, A., Payra, P., Mandal, B., and Kumar, V. 2024. Aquaponics: A pathway to boosting the aqua-agri revolution in eco-farming. In: *Sustainable Aquaculture: A Step Towards a*

Green Future in Fish Farming Publisher: Satish Serial Publishing House, Delhi, pp.183-200.

Diver, S, 2006. *Aquaponics- Integration of hydroponics with aquaculture.* ATTRA NCAT: Butte MT, USA, pp 1-16.

Goddek, S., Delaide, B., Mankasingh, U., Ragnarsdottir, K. V., Jijaki, H., and Thorarinsdottir, R. 2015. Challenges of sustainable and commercial aquaponics. *Sustainability*. 7(4): 4199-4224.

Khakyzadeh, V., Luque, R., Zolfigol, M.A., Vahidian, H.R, Salehzadeh, H., Moradi, V., and Xu, K.2015. Waste to wealth: a sustainable aquaponic system based on residual nitrogen photoconversion. *RSC Adv*. 5(5): 3917-3921.

Konig, B., Janker, J., Reinhardt, T., Villarroel, M., and Junge, R. 2018. Analysis of aquaponics as an emerging technological innovation system. *J. of clean. prod.* 180:232-243.

Shete, A.P., Verma, A.K., Chadha, N.K., Prakash, C., Peter, R.M., Ahmad, L., and Nuwans, K.K.T. 2016. Optimization of hydraulic loading rate in aquaponic system with Common carp (*Cyprinus carpio*) and Mint (*Mentha arvensis*). *Aquacult. Eng.* 72: 53-57.

Specht, K., Siebert, R., Hartmann, L., Freisinger, U. B., Sawicka, M., Werner, A., and Dierich, A. 2014. Urban agriculture of the future: an overview of sustainability aspects of food production in and on buildings. *Agr. Hum.values*. 3(1): 33-51.

Yep, B. and Zheng, Y. 2019. Aquaponic trends and challenges – a review. *J. of clean. prod.* 228: 1586- 1599.

Volume: 04 Issue No: 12

RUMEN METAGENOMICS AND ITS IMPLICATIONS IN ANIMAL NUTRITION

Article ID: AG-VO4-I12-15

Karishma Choudhary*, Vinod Kumar Palsaniya

*Ph.D. Scholar, Department of Livestock Production and Management

CVAS, Navania, Udaipur (RAJUVAS), Rajasthan, India

*Corresponding Author Email ID: choudharykarishma2531@gmail.com

Introduction

In recent years, advances in metagenomics have revolutionized the study of microbial communities, particularly in the rumen of herbivorous animals like cattle, sheep, and goats. The rumen, a fermentation chamber in the stomach of ruminants, hosts a diverse microbial ecosystem that plays a crucial role in digestion and nutrient absorption. Understanding the genetic composition of these microbial communities through metagenomics is unlocking new avenues for improving animal nutrition, health, and productivity.

What is Rumen Metagenomics?

Rumen metagenomics is the study of the collective genomes of microorganisms—such as bacteria, archaea, fungi, and protozoa—that inhabit the rumen. Unlike traditional microbiological approaches that isolate and study individual species, metagenomics provides a comprehensive view of the entire microbial community, offering insights into the functions of these microbes and how they interact with each other and their host.

Metagenomic tools enable the extraction and sequencing of DNA directly from rumen samples, bypassing the need for culturing. This approach provides a wealth of information about microbial diversity, metabolic pathways, and functional potential that directly impacts animal digestion and nutrition. With high-throughput sequencing technologies, researchers can map out the complex gene functions of rumen microorganisms and explore their interactions with feed components and host physiology.

The Role of Rumen Microbes in Animal Nutrition

The rumen microbiome plays an essential role in the breakdown of fibrous plant material, such as cellulose, which is otherwise indigestible by the animal's enzymes. Rumen microbes produce enzymes that break down complex carbohydrates into simpler compounds, which can then be absorbed by the host animal. Additionally, they aid in the synthesis of essential nutrients, including proteins and vitamins, and the fermentation of dietary fibers into volatile fatty acids (VFAs), which provide a significant energy source for the host.

There is increasing evidence that the composition of the rumen microbiome is influenced by various factors, such as diet, age, breed, and environmental conditions. For example, a diet high in forages typically promotes the growth of fiber-degrading microbes, whereas grain-based diets may favor microbes that produce lactic acid. Understanding these variations at the genetic level through metagenomics opens up new possibilities for optimizing livestock nutrition.

Key Findings and Insights from Rumen Metagenomics

1. **Microbial Diversity and Functionality:** Metagenomics has revealed that the rumen houses a highly diverse microbial community, with thousands of species from multiple domains of life. This diversity is critical for the efficient digestion of various feedstuffs, as different microorganisms specialize in different biochemical pathways. For instance, some microbes produce cellulases to break down plant cell walls, while others specialize in protein degradation or methane production.
2. **Methane Emission and Greenhouse Gas Reduction:** Methane is a potent greenhouse gas produced in the rumen by methanogenic archaea during the fermentation of food. The amount of methane produced by ruminants is a major environmental concern, contributing to climate change. Metagenomic studies have identified specific microorganisms involved in methane production, and researchers are exploring ways to manipulate these communities to reduce methane emissions. For example, altering the microbial composition with feed additives such as tannins or lipids can potentially reduce methane output while maintaining animal productivity. Rumen metagenomics is also being used to improve feed efficiency in livestock. By understanding the microbial pathways involved in the breakdown of specific feed components, nutritionists can design diets that promote the growth of beneficial microbes, improving digestibility and nutrient

absorption. This can lead to better growth rates, higher milk production, and reduced waste in animal husbandry.

3. **Adaptations to Dietary Changes:** Rumen microbes are highly adaptable to changes in diet. Metagenomic studies have shown that the microbial community can rapidly adjust its composition in response to dietary shifts. For example, when cattle are switched from grass to grain, there is a noticeable shift in the microbial community, with an increase in microbes that favor the breakdown of starch and a decrease in those that specialize in fiber digestion. Understanding tics at the genetic level enables nutritionists to fine-tune diets for maximum efficiency and productivity.
4. **Host-Microbe Interactions:** The relationship between the rumen microbiome and the host animal is symbiotic. Rumen microbes are crucial not only for digestion but also for modulating the immune system and preventing diseases. Metagenomic analyses have identified microbial genes associated with immune modulation, providing new insights into how microbial communities might be manipulated to improve animal health. Additionally, some microbes can help in detoxifying harmful compounds in the rumen, which may enhance animal welfare.

Implications

The insights gained from rumen metagenomics have broad implications for animal nutrition, health, and sustainability:

1. **Personalized Nutrition:** By understanding the specific microbial communities present in an animal's rumen, nutritionists can tailor diets to individual animals or groups. This personalized approach could optimize feed intake, reduce waste, and improve productivity. For example, by identifying animals with more efficient microbial communities, breeders could select for animals that convert feed into milk or meat more effectively.
2. **Feed Additives and Supplements:** Metagenomic data can inform the development of feed additives that enhance specific microbial populations. Supplements like probiotics, prebiotics, or enzyme additives can be tailored to promote the growth of microbes that improve digestion and nutrient absorption, leading to more sustainable animal production practices.

3. **Environmental Sustainability:** Reducing methane emissions and improving feed efficiency are critical components of sustainable livestock farming. Metagenomics provides the tools to identify which microbial communities contribute to methane production and to explore strategies for reducing emissions without compromising animal health or productivity. Such advancements are key to meeting global sustainability goals for agriculture.
4. **Disease Prevention and Animal Welfare:** Rumen metagenomics also opens up new avenues for preventing diseases in ruminants. By understanding the microbial interactions that protect against harmful pathogens, it may be possible to develop strategies to promote beneficial microbes, leading to improved animal health and reduced reliance on antibiotics.

Challenges and Future Directions

Despite the advances, there are still challenges in rumen metagenomics. The rumen is an incredibly complex environment, and isolating and characterizing the microbial communities is a formidable task. Furthermore, translating metagenomic data into practical applications in animal nutrition is still in its early stages. There is also a need for more standardized methodologies for sampling, sequencing, and data analysis.

As metagenomic technologies continue to improve, we can expect more precise and actionable insights into rumen microbiology. Future research may focus on microbiome engineering, where beneficial microbial strains are introduced or enhanced to optimize digestion and reduce environmental impacts, such as methane emissions.

Conclusion

Rumen metagenomics is transforming our understanding of animal nutrition and providing new tools for improving livestock productivity, health, and environmental sustainability. By harnessing the power of these microbial communities, we can develop more efficient, sustainable, and environmentally friendly animal farming practices. The future of animal nutrition is likely to be shaped by these microbial ecosystems, leading to healthier animals and more sustainable food production systems for the growing global population.

References

1. Hristov, A. N., et al. (2013). "Mitigation of methane emissions from ruminants." *Animal Production Science*, 53(5), 511-528.

2.Liu, J., et al. (2018). "Feed efficiency and rumen microbiome in cattle." *Frontiers in Microbiology*, 9, 2025.

3.McCann, J. C., et al. (2014). "Dietary influence on the rumen microbiota and feed efficiency in beef cattle." *Journal of Animal Science*, 92(3), 859-869.

4.Kelly, W. J., et al. (2015). "Insights from rumen microbiome studies in dairy cattle." *Animal Feed Science and Technology*, 211, 23-28

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

EFFECT OF FERTIGATION TECHNOLOGY ON YIELD, QUALITY AND LEAF NUTRIENT CONTENT IN NAGPUR MANDARIN UNDER HIGH DENSITY PLANTING

Article ID: AG-V04-I12-16

***Vipul M. Pardhi**

M.Sc. Scholar, Department of Soil Science and Agricultural Chemistry, College of Agriculture Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola 444104 Maharashtra, India

*Corresponding Author Email ID: vipulpardhi1999@gmail.com

Abstract

Water and nutrient use efficiency, both are considered as pre-requisites for sustained citrus productivity. Nagpur mandarin (*Citrus reticulata* Blanco) is one of the important fruits grown in central India, occupying 40% of the total area under citrus cultivation. In recent years, drip irrigation is gradually gaining popularity among the citrus growers of India. The growers are more interested in application of fertilizers through drip irrigation, as it saves manpower over traditional fertilization methods. However, the information regarding optimal fertilizer and irrigation scheduling through drip, and it's efficacy over conventional irrigation and fertilization methods, is meagre in citrus cultivation in India. This lack of information keeps the orchard growers in stack to adopt the fertigation technology in citrus. Various fertilizer levels singly and in combination were evaluated through fertigation in terms of response on the tree growth, fruit yield, quality, and leaf nutrient composition of Nagpur mandarin (Citrus reticulata Blanco). Besides, better mobility of nutrients, fertigation has been shown to have several advantages over broadcast application of granular fertilizer with respect to growth response, nutrient uptake, effective placement of nutrients and flexibility in application, frequency development of uniform root distribution in wetted zone, an important prerequisite for better NUE fruit yield and improvement in fruit quality.

Keywords: Nagpur mandarin, quality, yield, fertigation

Introduction

Citrus is often regarded as a queen of all fruits. It is the largest fruit farmed worldwide and one of the most significant subtropical fruit harvests. Next to mango and banana, it is the third-largest fruit farmed in India. The most commonly cultivated citrus species in India are *Citrus reticulate* (mandarin), *Citrus sinensis* (sweet orange), *Citrus aurantifolia* (acid lime), *Citrus aurantium* (sour or Seville orange), *Citrus limon* (lemon), *Citrus medica* (citron) and *Citrus paradise* (grapefruit). In India, it is grown on 462000 ha and produces 6026000 MT annually. (National Horticulture Board 2019).

Amongst all, Nagpur mandarin (Nagpuri santra) is considered one of the finest mandarins in the world, with a unique acid-sugar blend that imparts a sweet flavour. The Amravati and Nagpur districts of Maharashtra contribute about 80 % of total area under mandarin orchards in the state, sharing 48.88 % and 31.45 % respectively (Wankhede *et al.* 2017). In India Vidarbha is only citrus growing region with two fruiting seasons (Ambia and Mrig). The fruit available from September to December is Ambia, which has a slightly sour state. This is followed by the sweeter Mrig crop in February. Hence, Nagpur mandarin enjoys favourable climatic conditions to provide bulk production twice in a year.

Now-a-day fertilizers are becoming more expensive input in the market. Therefore, it is felt essential to learn more efficient use of these input. This challenge can be minimized by application of fertilizers by fertigation technology with drip irrigation system slow, measured and controlled rate to the active root zone. some researchers and growers established the utility of irrigation and fertigation system in fruit orchards for enhance growth and yield with superior quality produce.

Effect of fertigation fertigation technology in Nagpur mandarin

1. Optimized Nutrient Management: The findings of the experiment will be helpful to farmers for judicious application of fertilizers through fertigation to Nagpur mandarin in high density planting. This ensures that the crop receives the necessary nutrients in the right quantity, promoting healthy growth and higher fruit yield.

2. Leaf Nutrient Content: Analysing the nutrient content of leaves helps to farmers understand the nutritional status of the plants. Monitoring nutrient levels in leaves can provide insights, whether the current fertigation practices are meeting the nutritional requirements of Nagpur mandarin trees. Adjustments of fertigation levels can be made based on the observed nutrient values deficient whether or excess.

3. Higher Yield: Fertigation studies reveal the impact of different nutrient levels on fruit yield and fertigation regimes lead to optimal fruit production. This information is very crucial for maximizing the yield of Nagpur mandarin orchards, which is important for commercial production for export purpose. This is crucial for economic sustainability, as higher yields can lead to enhanced income of farmers.

4. Improved Quality of Fruits: The fertigation technology can guide farmers in achieving better fruit quality, such as size, colour, taste, TSS, Juice percentage and nutritional content. Improved fruit quality fetch higher market value and greater consumer satisfaction.

5. Resource Efficiency: Fertigation is known for its efficiency in resource utilization. By applying fertilizers through irrigation, farmers can reduce wastage of nutrients and ensure that plants take up the required elements more efficiently. This can lead to cost savings for farmers, making the cultivation process more affordable and enhanced nutrient use efficiency.

6. Environmental Impact: Precision nutrient management through fertigation can have positive environmental implications by minimizing the risk of nutrient runoff, leaching and groundwater contamination. Farmers adopting these practices can contribute to sustainable agriculture and environmental conservation.

7. Affordability and Cost Savings: Understanding the optimal fertigation levels enables farmers to use optimum quantities of fertilizers more judiciously. This approach can result in cost savings by avoiding excess use of fertilization, and it ensures that farmers invest in the right amount right placement, right time through right resources of fertilizers for getting maximum benefit.

8. Knowledge Transfer: The fertigation results can be disseminated among orange growers through extension services, training programs, mass media, social media or agricultural advisory services. This knowledge transfer is essential for empowering farmers with the advanced techniques and best practices, enhancing their ability to make informed decisions.

Conclusion

In nutshell, the effect of fertigation levels on Nagpur mandarin in high-density planting provides a roadmap for farmers to enhance productivity, improve fruit quality, and manage resources efficiently-all of which contribute to economic viability and sustainability orange growers in agriculture.

References

National Horticulture Board, Area production statistics for horticulture crops 2018-19 (Final), Ministry of Agriculture and Farmer Welfare, Government of India, Gurugram Haryana (accessed on 12 August 2022).

Wankhede, Y., N. M. Kale, P. P. Bhople and N. P. Jangwad, 2017. *Agric. Update*. 12(1): 52-60.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

COMMUNITY-BASED AQUACULTURE: EMPOWERING LOCAL COMMUNITIES

Article ID: AG-VO4-I12-17

[*]Yateesh DC[1], Sagar Ronad[2], Liton Paul[1] and Anurag Singh[1]

[1]Research Scholar, ICAR- Central Inland Fisheries Research Institute, Kolkata- 700120 West Bengal, India

[2]PhD Scholar, ICAR-Central Institute of Fisheries Education, Panch Marg, off Yari Road, Andheri (West), Mumbai-400061 Maharashtra, India

*Corresponding Author Email ID: yateeshdc100@gmail.com

Abstract

Community-based aquaculture (CBA) has gained recognition as an effective and inclusive strategy for sustainable fisheries management and food production, benefiting both rural and coastal communities. This approach leverages collective action and shared resources among small-scale fishers and local communities to overcome individual limitations, such as financial constraints and limited manpower. The studies highlighted that effective CBA encompasses community engagement, collaboration with extension services, community awareness, team building, training, local institutional strengthening, business planning, and market infrastructure development. Drawing insights from case studies, such as women-led aquaculture initiatives in Odisha, India, this chapter highlights how CBA empowers individuals, supports economic and food security, and enhances environmental resilience. The findings underscore the transformative potential of CBA in improving livelihoods, especially for marginalized fishing communities, while also contributing to ecosystem restoration and sustainable development.

Key words- Community Based Aquaculture, Livelihood, small-scale fishers

Introduction

The Indian fisheries sector has experienced remarkable growth (10.34%), providing significant livelihood opportunities for millions (DoF, 2022). The role of aquaculture in enhancing the contributions to the fisheries sector is pivotal. Both inland and marine aquaculture have witnessed substantial advancements, leading to increased income generation and employment opportunities. This growth can largely be attributed to technological upgrades that have attracted major industry players, resulting in a thriving sector supported by adequate capital investment.

However, the fisheries resources being Common (s) Traditional and small-scale fishers always juggling with competition, multiple governance issues and often struggle to maximize their income through aquaculture due to financial constraints, as they typically operate as individual units without sufficient capital or manpower to initiate such enterprises. Additionally, many farmers with small ponds face limitations regarding capital and land.

In this context, community-based aquaculture emerges as a promising solution. By strengthening collaboration among local fishers and farmers, this approach has the potential to address existing challenges effectively. Community-based aquaculture not only empowers individuals but also enhances the sustainability of local fisheries, making it a crucial component in the broader landscape of economic development and food security.

Before we understand the dynamics of the community-based aquaculture few interesting questions may arise in your mind like, what exactly is community-based aquaculture? What are the specific benefits it offers to local communities and the environment? How can small-scale fishers and farmers collaborate effectively to maximize their resources and knowledge? What challenges do they face in implementing community-based aquaculture, and what strategies. By answering these questions, we can gain a deeper understanding of how community-based aquaculture empowers rural impoverished fishing communities and, most importantly, supports conservation efforts. This chapter addresses these issues in various sections.

Community-based aquaculture as a catalyst of transformative change in lives of communities:

Historically, the capture fisheries sector in India, both marine and inland, has been caste-based, with specific communities intrinsically connected to the profession. These communities have maintained strong group norms over the years. However, socio-ecological changes and increasing fishing pressures have begun to alter these dynamics. Despite these challenges, local institutions such as cooperatives and self-help groups (SHGs) continue to play a vital role in collectively governing fisheries in common property resources.

In the inland sector, rights to water bodies of certain sizes are now largely vested in state departments, although the responsibility for revenue generation and collective management often remains with cooperatives. These cooperatives, formed by the communities themselves, prioritize the collective interests of fishers. However, cooperatives across India are currently facing significant governance and financial challenges that need urgent attention.

In the marine sector, small-scale fishers remain undefined as a distinct group and continue to struggle for access to resources, facing intense competition. Despite these issues, there is significant potential for community-based aquaculture in both inland and marine sectors. Many places already have community-based capture fisheries, such as the beel fisheries in Kolkata, managed through cooperatives. A shift toward community-based aquaculture where local communities collectively manage and operate aquaculture systems, with decision-making, benefits, and responsibilities shared among the group, would be beneficial, in coastal areas with opportunities like seaweed farming, floating cages, and marine ornamental fish rearing. Similarly, inland areas have potential for pen culture, cage culture, hatcheries, and seed rearing.

According to De and Saha (2007), Community-based aquaculture (CBA) is a useful tool for implementing scientific aquaculture programs based on participation principles and the basis of common interest groups working together regardless of sex and age. Haque and Dey (2017) stated community-based fish culture (CBFC) technology required suitable topography and institutional arrangements. It also ensures participation of all the stakeholders of aquaculture such as landlords, renting agents and farmers.

By transitioning to community-based aquaculture, impoverished fishing communities can utilize their traditional skill sets, protect their identity as fishers, and improve their economic well-being. This shift can provide new livelihoods while preserving their cultural heritage and enhancing local economies

What value does Community based aquaculture add to community and ecosystem a success story

As discussed in the earlier section, institutions play a crucial role in community-based aquaculture and have the potential to transform the lives of impoverished communities. In this section, let’s explore a real-life example of successful community-based aquaculture in Odisha, India, and how it has significantly changed the lives of women in these communities.

Community based aquaculture for enhanced nutrition: A case study in Odissa

The women-centric government program in Odisha has had a profound impact, thanks to the concerted efforts of various governmental departments and proactive bureaucratic support. A significant advancement in this initiative is the government's long-term leasing policy of gram panchayat (GP) ponds to women self-help groups (WSHGs), complemented by financial and technical assistance, which has fostered the grassroots acceptance of community-based aquaculture. This acceptance has been bolstered by comprehensive training, doorstep support, and the adoption of best management practices (BMPs) such as pond preparation, feeding regimes, and water quality monitoring. These measures have enhanced the capacity of WSHGs, leading to sustainable production and multifaceted improvements in economic, environmental, and food security realms.

Moreover, the scheme has played a crucial role in fostering the economic empowerment of women at the village level, as illustrated in Figure 2, which connects the program's outcomes to the Sustainable Development Goals (SDGs). The initiative directly contributes to SDGs 1, 2, and 5, while also indirectly supporting SDGs 3, 13, 16, and 17.

Resource Utilization: By promoting nutrition-sensitive carp-mola polyculture managed by women-led community institutions, the program showcases a sustainable approach to utilizing public water bodies. Once neglected, GP tanks have transformed into vital community assets, providing economic opportunities while also delivering environmental and aesthetic benefits through the removal of aquatic weeds and restoration of pond dikes.

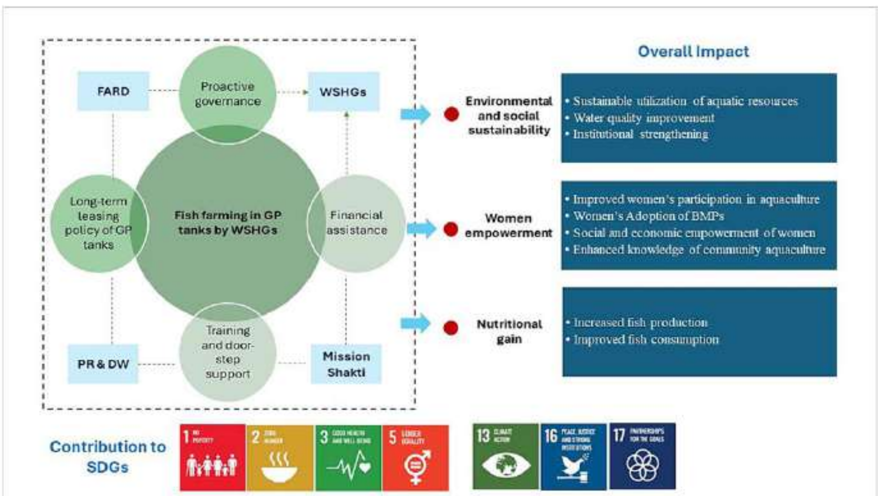
Economic Empowerment: In terms of direct income, the scheme has significantly empowered women economically, with each WSHG earning an annual income of INR 1,06,031 from fish farming in GP tanks. Research indicates that women's active involvement in small-scale aquaculture enhances income and food security, leading to improved overall welfare outcomes.

Improved Fish Production: The initiative's emphasis on low-input modified-extensive polyculture has not only increased overall fish production but also enhanced the productivity of community ponds across Odisha. This focus has bolstered income and improved access to nutrient-rich fish, with carp-mola polyculture demonstrating superior production, income, and consumption rates compared to traditional carp polyculture.

Improved Nutrition: Nutritional enrichment is another critical aspect of the program. By ensuring regular availability of live and fresh fish at affordable prices, it has significantly increased fish consumption among local communities. WSHGs have distributed and consumed an average of 69 kg of fish per year per group, contributing to overall food security.

Climate Resiliency: The scheme promotes climate resiliency by introducing climate-smart practices, such as advance-sized carp fingerling stocking. Greater pond depth in GP tanks helps mitigate water stress during prolonged summer periods, ensuring the sustainability of the initiative amid fluctuating environmental conditions.

In summary, community-based aquaculture in Odisha exemplifies a successful model of empowerment and sustainability, transforming the lives of women and enhancing the resilience of local ecosystem



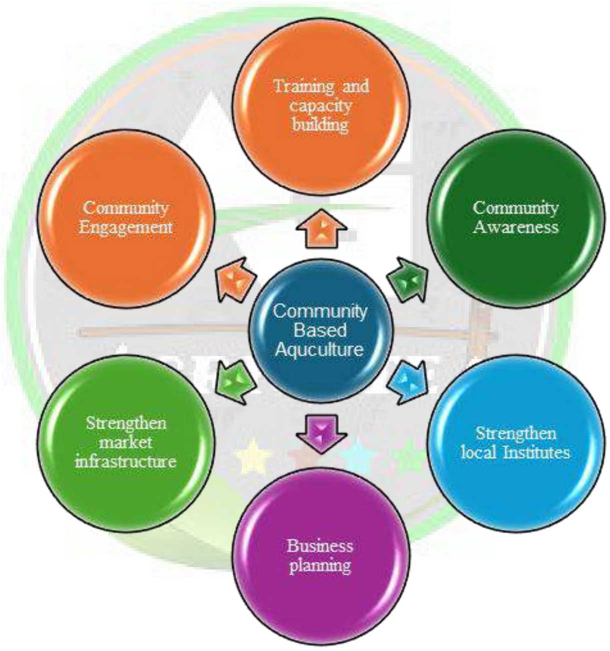
Source: Dubey *et al*. (2024)

What are the challenges faced in community based Aquculture

Community-based aquaculture practices are often easier to manage compared to individual efforts when starting an aquaculture venture. However, as literature suggests, these initiatives typically require financial support systems, especially during the initial phase. This makes them dependent on external sources such as government and non-governmental initiatives (Ateweberhan *et al*., 2018). Unfortunately, when the necessary support is not provided, it can become a critical obstacle, particularly at the outset of the venture. Community based aquaculture lacks collaborations with Research institutes and other extension functionaries. Which are actually very important in disseminating new, economically technologies to the farmers. There are so many areas where lot of scope for community-based aquaculture but lack of skills in new technologies in fishers discourage them from starting venture, so skills development programme should be given to fishers.

Way Forward for Community Based Aquaculture

Community-based aquaculture (CBA) has emerged as a sustainable and inclusive approach to fisheries management and food production, particularly in rural and coastal communities. The framework for CBA involves community engagement, convergence of Extension functionaries, Community Awareness, Team Assembly and training, Strengthen local Institutes, Business planning, strengthen market infrastructure, etc. The framework prepared based on literature available on CBA



Conclusion

Community-based aquaculture presents an inclusive and effective model for fisheries and food production, transforming lives in coastal and rural areas. By strengthening community cooperation, integrating resources, and supporting skill-building, CBA not only provides sustainable livelihoods but also promotes environmental stewardship and food security. Successful cases, like those in Odisha, demonstrate the importance of strong institutions, skill development, and market access for the success of community-led aquaculture. Addressing challenges, including funding and partnerships with research bodies, will be essential to unlocking CBA's full potential and ensuring long-term success for marginalized communities.

References

Ateweberhan, M., Hudson, J., Rougier, A., Jiddawi, N.S., Msuya, F.E., Stead, S.M. and Harris, A., 2018. Community based aquaculture in the western Indian Ocean: challenges and opportunities for developing sustainable coastal livelihoods. Ecology and Society, 23(4).

De, H.K. and Saha, G.S., 2007. Community-based aquaculture-An evaluation. Journal of Rural Development, 26(1), pp.137-146.

Dubey, S.K., Padiyar, A., Chadag, V.M., Shenoy, N., Gaikwad, A.B., Ratha, B.C. and Belton, B., 2024. Scaling community-based aquaculture for enhanced nutrition and women's empowerment: lessons from Odisha, India. Frontiers in Sustainable Food Systems, 8, p.1412686.

Haque, A.M. and Dey, M.M., 2017. Impacts of community-based fish culture in seasonal floodplains on income, food security and employment in Bangladesh. Food Security, 9, pp.25-38.

https://dof.gov.in/sites/default/files/2023-08/HandbookFisheriesStatistics19012023.pdf

Volume: 04 Issue No: 12

RESPONSE OF WHITE ONION TO DIFFERENT LEVELS OF FERTILIZERS UNDER SOUTH KONKAN COASTAL ZONE

Article ID: AG-V04-I12-18

M. S. Talath*

Programme Coordinator, KVK Roha Raigad

Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth (Dr. BSKKV), Dist Raigad, M.S., India

Corresponding Author Email ID:* manoj84048@yahoo.co.in

Abstract

White Onion (*Allium cepa* L.) is originated from the Central Asia region and this crop belongs to *Amaryllidaceae* or *Alliaceae* family. In India it has very long history. Indians known this crop from prehistoric times. Onion is also popularly known as poor man's 'Kasturi' or "Queen of kitchen". It is said that cultivation of onions has been there since 5000 BC. In India onion is mainly produced in states like Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Gujrat, Bihar, Andhra Pradesh. But white onion in Maharashtra mainly cultivated in Raigadh, Palghar, Nashik and Ahmednagar districts. Onions are more susceptible to nutrient deficiencies than most crop plants because of their shallow and unbranched root system hence they require and often respond well to addition of fertilizers (Brewster, 1994). An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally leading to higher productivity. The field experiment entitled "Response of white onion (*Allium cepa* L.) to different levels of fertilizer under South Konkan coastal zone" was conducted at Agronomy Farm, College of Agriculture, Dapoli, Dist., Ratnagiri (M.S), India during *rabi* season of 2020-21. The field experiment was laid out in a Randomized Block Design. Treatments are comprised with different levels of fertilizers. Thus, there were seven treatment combinations, replicated thrice. At harvest maximum plant height was recorded is 51.81 cm in application of NPK @ 150:50:25 kg/ha and lowest height recorded was 32.97 cm which was absolute control. At harvest, treatment T_5 recorded significantly maximum number of leaves (9.60) as compared to

all other treatments, except treatment T_4 (9.13) which was at par. At harvest, treatment T_5 (2.00 cm) found statistically significant over all other treatments regarding mean diameter of bulb neck. Similarly, at harvest, highest dry matter (9.58 g) was found in treatment T_5 where 150:50:25 Kg NPK per ha was applied and lowest dry matter (4.82 g) was found in treatment T_1 which was absolute control. These vegetative characters are primary characters which decide vigour of the crop and influence on yield through enhanced dry matter production. The highest yield (14.89 t ha^{-1}) was found in treatment T_5 (150:50:25 NPK kg ha^{-1}) and lowest yield (7.71 t ha^{-1}) was found in treatment T_1 which was absolute control. Higher yield in white onion due to application of fertilizers dose may be attributed to sustained nutrient supply and also as result of better utilization of applied nutrients and slow release of nutrients throughout the crop growth. The maximum B:C ratio (2.07) was observed in treatment T_5 where NPK @ 150:50:25 Kg per ha was applied which may be due to application of fertilizer dose. Hence, it can conclude that 25 percent Potassium application can be curtail for getting highest growth attributing characters, yield and yield attributing characters as well as maximum gross return, net return and highest B:C ratio in White onion under lateritic soils of South Konkan coastal zone.

Key word: White Onion, nutrient management, B:C ratio.

Introduction

White Onion (*Allium cepa* L.) is originated from the Central Asia region and this crop belongs to *Amaryllidaceae* or *Alliaceae* family. In India it has very long history. Indians known this crop from prehistoric times. Onion is also popularly known as poor man's 'Kasturi' or "Queen of kitchen". It is said that cultivation of onions has been there since 5000 BC. Even doctors of 16th century prescribed onions for many diseases like infertility on women. Studies also point out that onion has the power to balance blood sugar levels. Other than medicinal contributions white onions are also tasty and are used for many culinary across the world. The main constraint of low production and productivity of onion crop is the inadequate supply of nutrients. The role of fertilizer in boosting agricultural productivity during past decades is now well recognized (Singh and Singh, 1998). Fertilizer is a major factor for yield performance and to get maximum monetary returns per unit cost. The information is scanty about response of onion to fertilizer as well as proper fertilizer management in *rabi* season under Konkan condition.

Medicinal properties of the onion have been seen from very long time in 'Charak Samhita' it is a book written by 'Charak' in ancient India. This is a medicinal treaty in Sanskrit. White onions an inevitable part of Indian cooking recipes. According to researchers white Onions are super healthy with Vitamin C, flavonoids and Phytonutrients. Flavonoids present in white onions will lower the risk of some diseases like stroke, Parkinson's and Cardiovascular disease. Except this it also contains fibres, folic acids, antioxidants, and anti-bacterial agents. White onions are best suited for both raw and cooked applications such as roasting, grilling, sautéing and frying. When used fresh, the onions can be diced and tossed into a salad, minced and mixed into white sauces, salsa and guacamole or layered of sandwiches, burgers and wraps. White onions can also be chopped and added to soups, stews and stocks, served with roasted meats or used as a pizza topping. White onions are favoured by chefs and home cooks for their mild, semi-sweet and sharp flavour.

Anti-inflammatory properties of white onions help to reduce high Blood pressure and protect against blood clots. White onion also rich in Selenium which stimulates immune functions and helps to reduce inflammation. The agents like flavonoids and sulphur in white onions helps in thinning of blood which ultimately helps blood flow smoothly through veins and arteries in human body. White onion motivates a healthy heart in many ways including lowering heart attack risk and lowering blood pressure. The quercetin in white onions helps to prevent plague build up in arteries, which reduce the risk to stroke and heart attack.

In India onion is mainly produced in states like Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Gujrat, Bihar, Andhra Pradesh. The stake of onion production in this state is 43.31%, 15.20%, 8.47%, 5.80%, 4.63%, 4.89% and 3.65% respectively (Anonymous, 2020). But white onion in Maharashtra mainly cultivated in Raigadh, Palghar, Nashik and Ahmednagar districts.

In recent years onion crop get more importance due to its export potential and because of its medicinal properties. In Maharashtra, Onion crop grown in seasons like *Kharif* season, Late *Kharif* season, *Rabi* season and Late *Rabi* season. In Coastal zone districts farmers in Maharashtra mainly grown this crop in *Rabi* season. Under Konkan conditions excess rainfall is the main constraint for growth and development of white onion during *kharif* season hence farmers are not taking more than one crop in a year.

Onions are more susceptible to nutrient deficiencies than most crop plants because of their shallow and unbranched root system hence they require and often respond well to addition of fertilizers (Brewster, 1994). An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally leading to higher productivity. The application of different doses of nitrogen increased plant growth and yield of onion (Patel *et al.*, 1992). Phosphorus has its beneficial effect on early root development, plant growth, yield and quality of crop produce (Balai, 2002). Metabolic activities of chloroplast are also influenced by potassium level in their organelles. Potassium also activates the fat producing enzymes in plant Effect of Nutrient Management on growth, yield, soil nutrient availability and uptake of nutrients has been studied by a number of scientists and the results vary according to varieties, soil and weather conditions.

Different cultural practices and growing environments are known to influence yield and quality of onion bulb. So far, research in the country was mainly focused on the identification of superior cultivars of onions and adopting improved management practices. Mineral nutrition is main that affects yield and quality of onion (Chung, 1989). Nitrogen, Phosphorus and Potassium are often referred to as the primary macronutrients because of the probability of plants being deficient in these nutrients and because of the large quantities taken up by plants from the soil relative to other essential nutrients (Marschner, 1995). Nitrogen comprises 7% of total dry matter of plants and is a constituent of many fundamental cell components (Bungard, 1999). It is one of the most complexes in behaviour, occurring in soil, air and water in organic and inorganic forms. For this reason, it poses the most difficult problem in making fertilizer recommendations (Archer, 2002). Plant demand for N can be satisfied from a combination of soil and fertilizer to ensure optimum growth.

The main constraint of low production and productivity of onion crop is the inadequate supply of nutrients. The role of fertilizer in boosting agricultural productivity during past decades is now well recognized (Singh and Singh, 1998). Fertilizer is a major factor for yield performance and to get maximum monetary returns per unit cost. The information is scanty about response of onion to fertilizer as well as proper fertilizer management in *rabi* season under Konkan condition. Hence taking into account it was planned to conducted an experiment entitled “Response of White onion to different levels of fertilizers under South Konkan coastal zone” with following objectives:

1) To study the effect of different levels of fertilizer on growth and performance of white onion.
2) To study the effect of different levels of fertilizer on yield of White onion.

3) To study the economics of various treatments.

MTHODOLOGY

The field experiment entitled "Response of white onion (*Allium cepa* L.) to different levels of fertilizer under South Konkan coastal zone" was conducted at Agronomy Farm, College of Agriculture, Dapoli, Dist., Ratnagiri (M.S), India during *rabi* season of 2020-21.The topography of the experimental plot was uniform. The selection of site was considered on the basis of suitability of the land for cultivation of white onion. The topography of the experimental plot was uniform and levelled.

The field experiment was laid out in a Randomized Block Design. Treatments are comprised with different levels of fertilizers. Thus, there were seven treatment combinations, replicated thrice. The treatment details along with the symbols used in the layout plan are as follows.

Treatment details	**Symbol used**
1) Absolute control	T_1
2) 100:50:50 (N:P:K kg ha^{-1})	T_2
3) 100:50:25 (N:P:K kg ha^{-1})	T_3
4) 150:50:50 (N:P:K kg ha^{-1})	T_4
5) 150:50:25 (N:P:K kg ha^{-1})	T_5
6) 100:25:50 (N:P:K kg ha^{-1})	T_6
7) 100:25:25 (N:P:K kg ha^{-1})	T_7

Experimental details :

a)	Experimental design	:	Randomized Block design
b)	No. of replications	:	Three
c)	Total number of plots	:	7
d)	Spacing	:	30 cm x 10 cm
e)	Plot size	:	Gross - 6.0 m x 2.0 m
			Net - 5..4 m x 1.8 m
f)	Crop	:	White onion (*Allium cepa* L.)
g)	Variety	:	Alibagh local
h)	Season	:	*Rabi* 2020-2021

i) RDF : 100:50:50 (N:P:K) kg ha^{-1}

The data related to each character of the crop was analyzed statistically by using standard method of 'Analysis of variance' as applicable to Randomized Block design (Panse and Sukhatme, 1967). The significance of the treatment difference was tested by 'F' test (variance ratio). Further, the critical difference (CD) at 5 per cent level of probability was worked out for comparison and statistical interpretation of significance among the treatment means.

RESULT AND DISCUSSION:

The data pertaining to mean growth characters of white onion were presented in Table 1. The results in present investigation revealed that application of different fertilizers and their application at various growth stages of onion showed significant variation between each other and also at different growth stages. The increase in plant height and number of leaves/plants with the addition of nitrogen may be attributed to more availability of nutrients, especially N, which enhances the number of leaves by its simulative effect on cell division and cell enlargement that in turn may increase number of leaves and leaf dimensions. Similar findings were reported by (Tiwori *et al*., 2002).

Table 1. Mean growth characters of White onion as affected periodically by different treatments.

Treatments (NPK kg ha^{-1})	At Harvest			
	Mean plant height (cm)	Mean No of leaves	Mean diameter of bulb neck (cm)	Dry matter production (gm)
T1: Absolute control	32.97	6.67	1.37	4.82
T2: 100:50:50	45.67	8.20	1.80	6.24
T3: 100:50:25	46.84	8.73	1.79	6.49
T4: 150:50:50	50.38	9.13	1.92	8.51
T5: 150:50:25	51.81	9.60	2.00	9.58
T6: 100:25:50	43.42	8.13	1.65	5.69

T7: 100:25:25	42.15	7.93	1.59	5.68
S.E.(m)±	0.52	0.20	0.02	0.12
C.D. at 5%	1.60	0.62	0.07	0.37
General mean	44.45	8.34	1.73	6.71

At harvest maximum plant height was recorded is 51.81 cm in application of NPK @ 150:50:25 kg/ha and lowest height recorded was 32.97 cm which was absolute control. The increase in height could be attributed to its involvement as building blocks in the synthesis of amino acids, as they link together and form proteins and make up metabolic processes required for plant growth. Onion plants benefited from application of nitrogen from 90 to 120 kg^{-1} compared to the unfertilized crops as reported by (Aklilu, 1997). Kumar *et al*.,1998 reported that N at 150 kg ha-1 gave the best result with regard to plant height, diameter of the thickest stem, number of leaves per plant, bulb diameter, bulb fresh weight and dry weight and bulb yield. This result is in agreement with Rizk,1997 who reported that increasing N application generally increased growth parameters of onion plant. The results obtained are also in close agreement with Zanjad *et al.*,2020 and Patil,1983 with regard to phosphorous application. At harvest, treatment T_5 recorded significantly maximum number of leaves (9.60) as compared to all other treatments, except treatment T_4 (9.13) which was at par. Simultaneously, treatments T_3, T_2 and T_6 were at par with each other. Treatment T_1 (absolute control) had inferior to all other treatments. At harvest, treatment T_5 (2.00 cm) found statistically significant over all other treatments regarding mean diameter of bulb neck. At harvest, highest dry matter (9.58 g) was found in treatment T_5 where 150:50:25 Kg NPK per ha was applied and lowest dry matter (4.82 g) was found in treatment T_1 which was absolute control. These vegetative characters are primary characters which decide vigour of the crop and influence on yield through enhanced dry matter production. Enhanced plant growth characters might be due to higher nutrient availability as well as better nutrient uptake by the crop (Pitchai *et al*., 2001). Major nutrient supplied by the inorganic fertilizers will be utilized quickly by the crop. Results are found closely associated with findings of Yadav *et al.* (2020).

The quantitative assessment of crop productivity growth characters and yield contributing characters influenced the total bulb yield significantly. The data pertaining to yield of white onion were presented in Table 2 and graphically depicted in Fig.2. It is observed that yield of crop increase by increasing levels of Nitrogen and Phosphorous but there is no much effect of Potassium, these results are had similar findings with Patil (1983). The highest yield (14.89 t ha^{-1}) was found in treatment T_5 (150:50:25 NPK kg ha^{-1}) and lowest yield (7.71 t ha^{-1}) was found in treatment T_1 which was absolute control. Higher yield in white onion due to application of fertilizers dose may be attributed to sustained nutrient supply and also as result of better utilization of applied nutrients and slow release of nutrients throughout the crop growth. Different researchers reported bulb yield improvement in response to fertilization (Singh et al., 1989; Patel and Patel, 1990).

Table 2. Yield (t ha^{-1}) of White onion as affected by different treatments.

Treatments	Yield (t ha^{-1})
T1: Absolute control	7.71
T2: 100:50:50 NPK kg ha^{-1}	9.71
T3: 100:50:25 NPK kg ha^{-1}	10.29
T4: 150:50:50 NPK kg ha^{-1}	13.71
T5: 150:50:25 NPK kg ha^{-1}	14.89
T6: 100:25:50 NPK kg ha^{-1}	8.86
T7: 100:25:25 NPK kg ha^{-1}	8.89
S.E.(m)±	0.36
C.D. at 5%	1.12
General mean	10.58

There are reports indicating that different plant growth characters (plant height and bulb diameter) are known to increase the yield of onion (Nasreen et al., 2007). Thus, helping to form more photosynthates and translocating the same from source to sink. This result found closely related with results of Warade *et al.* (1996), and Damase *et al.* (2014).

The data pertaining to mean Economics of white onion were presented in Table 3 revealed that, the maximum B:C ratio (2.07) was observed in treatment T_5 where NPK @ 150:50:25 Kg per ha was applied which may be due to application of fertilizer dose. The results are its links with Warade *et al.* (1996 and Damase *et al.* (2014) also found maximum B:C ratio in treatments where fertilizer doses are applied compared to control.

Table 3. Economics of white onion as affected by different treatments

Treatments (NPK kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Total gross return (Rs ha^{-1})	Total net return (Rs ha^{-1})	B:C Ratio
T1: Absolute control	130465	166860	36394	1.28
T2: 100:50:50	151568	258520	106951	1.70
T3: 100:50:25	153546	275190	121643	1.79
T4: 150:50:50	161723	315020	153296	1.94
T5: 150:50:25	165396	341860	176463	2.07
T6: 100:25:50	145167	228380	83212	1.57
T7: 100:25:25	142583	217680	75096	1.52
S.E.(m)±	-	-	-	0.07
C.D. at 5%	-	-	-	0.20
General mean	150064	257644	107579	1.70

Conclusion

Application of 150:50:25 Kg NPK ha^{-1} (T_5) to white onion significantly recorded highest growth attributing characters, yield as well as gave maximum gross return (341860 Rs ha^{-1}), net return (176463 Rs ha^{-1}) and highest B:C ratio (2.07) which was best among all other treatments, but at par with application of 150:50:50 kg NPK ha^{-1} (T_4). Hence, it can conclude that 25 percent Potassium application can be curtail for getting highest growth attributing characters, yield and yield attributing characters as well as maximum gross return, net return and highest B:C ratio in White onion under lateritic soils of South Konkan coastal zone.

References

Aklilu, L. (1997). Onion research and production in Ethiopia. *Acta Hortic*., **433**: 95-97.

Anonymous, (2020). Monthly report onion, June, 2020. Horticultural statistics division, Department of Agriculture and Farmers welfare. Ministry of Agriculture and farmers welfare, GOI, New Delhi, India.

Archer, J. (1988). Crop Nutrition and Fertilizer Use. 2nd ed. Farming Press Ltd. Wharfedaale Road, Ipswich.

Balai, R. P. (2002). Response of mungbean (*Vigna radiata* L.) to phosphorous and bacterial culture in loamy sand. M.Sc. (Ag.) Thesis, RAU, Bikaner.

Brewster, J.L. (1994). Onions and Other Vegetable Alliums. *CABI Publishing. Wallingford*, UK. 236p.

Bungard, R. A., Wingler, A., Morton, J. D. and Andrew, M. (1999). Ammonium can stimulate nitrate and nitrite reductase in the absence of nitrate in Clematis vitalba. *Plant Cell Environ*., 22: 859-866.

Chung, B. (1989). Irrigation and bulb onion quality. *Acta Horticulture*. **247**: 233-237.

Damase, D. N., Bhalekar, M. N. and Pawar, P. K. (2014). Effect of INM on growth and yield of Garlic. *The Bioscan*. **9**(4): 1557-1560.

Kumar, H., Singh, J. V., Ajay, K., Mahak, S., Kumar, A. and Singh, M. (1998). Studies on the influence of nitrogen on growth and yield of onion cv. Patna Red. *Indian J. of Agril. Res.* **32**: 88-92.

Marschner, H. (1995). Mineral Nutrition of Higher Plants, 2nd ed. *Academic press*. London. 196p.

Nasreen, H. F., Haque, M. M., Farid, A. T. M. (2007). Nutrient uptake and yield of onion as influenced by nitrogen and sulphur fertilization. *Bangladesh J. Agric. Res.*, **32**(3): 413-420.

Panse, V. G. and Sukhatme, P. V. (1967). Statistical methods for agricultural workers, I. C. A. R., New Delhi, India.

Patel, I. J. and Patel, A. T. (1990). Effect of nitrogen and phosphorus levels on growth and yield of onion (*Allium cepa* L.) cv. Pusa Red. *Res. Gujarat Agric. Univ.*, **15**: 1-5.

Patel, K. P., Patel, J. C., Patel, B.S. and Jadaria, S. G. (1992). Yield and nutrient uptake by onion (*Allium cepa* L.) as influenced by irrigation, nitrogen and phosphorous. *Indian Journal of Agron.* **37** (2): 395-396.

Patil, R. S. (1983). Genetic Variability in respect of storage quality of onion. M.Sc. (Agri.) Thesis submitted to M. P. K. V., Rahuri (M.S), India.

Pitchai, S. J. Prabhakaran, C. and Saliha, B. B. (2001). Evaluation of the effect of different organic nitrogen on yield and quality of tomato. *National Seminar*, *Annamalai Uni*. p. 118.

Rizk, F. A. (1997). Productivity of onion plant (*Allium cepa* L.) as affected by method of planting and NPK application. *Egyptian Journal of Hort.* **24**(2): 219-238.

Singh, T., Singh, S. B. and Singh, B. N. (1989). Effect of nitrogen, potassium and green manuring on growth and yield of *rainy* season onion (*Allium cepa* L.). *Narendra Deva J. Agric. Res.*, **4**(1): 57-60.

Singh, Y.P. and Singh, V. (1998). Response of Nitrogen and Zinc levels on biomass, quality and chemical composition of forage sorghum. *Forage Res.*, **24**(1): 21-23.

Tiwori, R.S., Ankur, A. and Sengar, S.C. 2002. Effect of doses and methods of nitrogen application on growth, bulb yield and quality of "Pusa Red" onion (*Allium cepa*). *Indian J. of Agric. Sci.*, **72**(1):23-25.

Yadav, L. N., Ilhe, S. S. and Deshmukh, P. L. (2020). Effect of Micro-Sprinkler Irrigation and Nitrogen Levels on rabi Onion (*Allium cepa* L.). National Webinar on Approaches Towards Onion Cultivation, 26-27 May, 2020.

Zanjad, A. B., Pimpale, A. R., Wadatkar, S. B., Ghawade, S. M. and Hadole, S. S. (2020). Comparative performance of growth and yield parameters of onion under different fertilizer levels in surface and drip irrigation. *Multilogic in Science.*, **10**(33): 732-735.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

DROUGHT RESILIENCE IN RICE: EXPLORING STRATEGIES AND UNDERSTANDING THE MECHANISMS OF TOLERANCE AND ADAPTATION

Article ID: AG-VO4-I12-19

Vignesh Mohanavel*, Rakshana Palaniswamy, Sudha Manickam, Raghu Rajasekaran and Raveendran Muthurajan*

Department of Plant Biotechnology, Centre for Plant Molecular Biology and Biotechnology, Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India

*Corresponding Author Email ID: mohanvicky777@gmail.com

Abstract

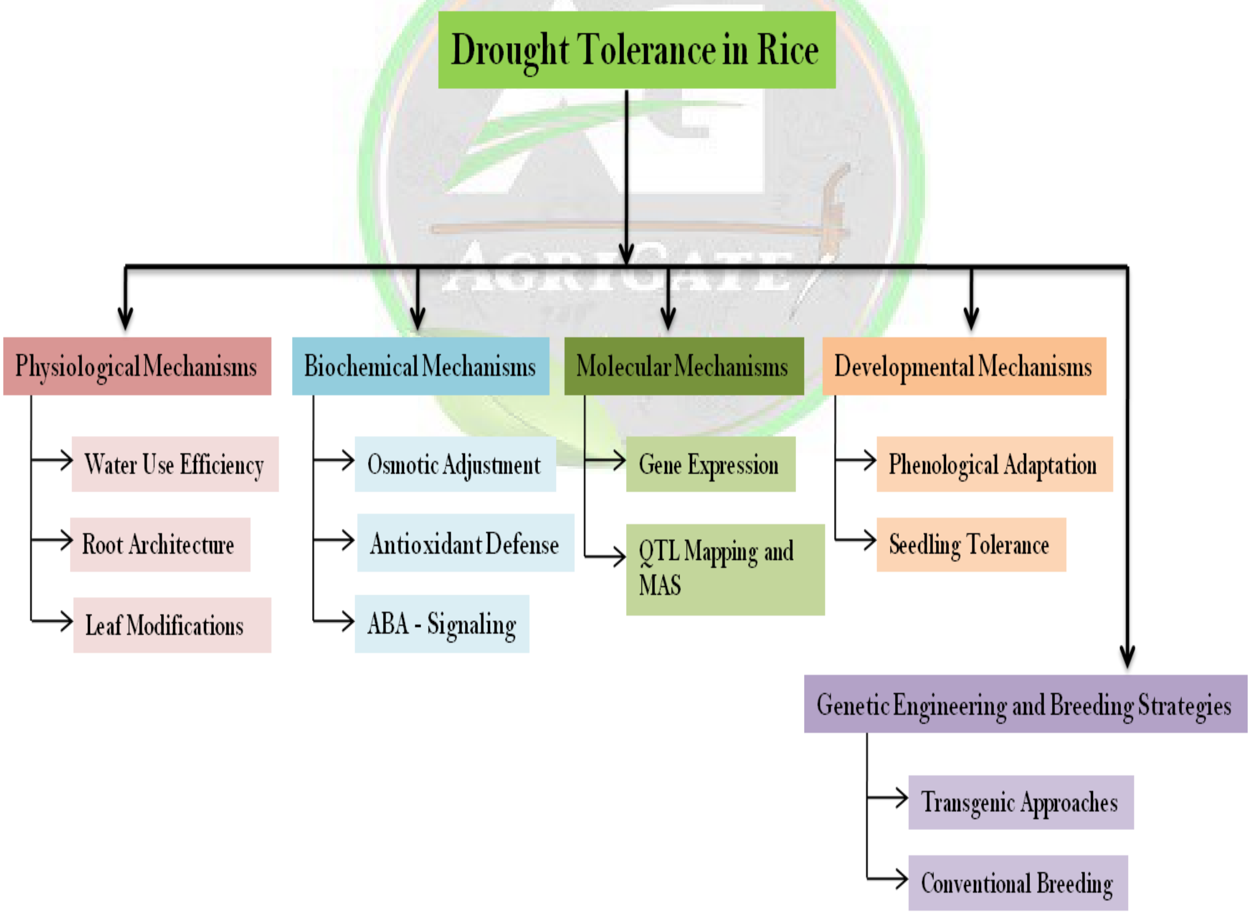
Drought tolerance in rice is an essential component for maintaining food security amid the challenges posed by climate change and diminishing water resources. This article delves into the intricate mechanisms that contribute to drought tolerance in rice, focusing on physiological adaptations such as improved water use efficiency and alterations in root architecture. Furthermore, we investigate biochemical responses that include osmotic adjustment and antioxidant mechanisms, which safeguard plants against oxidative stress. The discussion also emphasizes the significance of molecular mechanisms, such as gene expression and signaling pathways, while highlighting recent advancements in genetic engineering and breeding techniques aimed at producing resilient rice varieties. By synthesizing knowledge from these various approaches, this article emphasizes the critical need to enhance drought resilience in rice to ensure agricultural productivity and fulfill global food requirements.

Introduction

As global climate change progresses, the agricultural sector encounters unprecedented challenges, especially in areas where water scarcity is increasingly prevalent. Rice, a fundamental food source for over half of the world's population, is particularly susceptible to drought, which can severely affect both yield and food security. The ability of rice to tolerate drought is not merely advantageous; it is critical for maintaining production amidst environmental pressures.

This article examines the diverse mechanisms that provide drought tolerance in rice, focusing on physiological adaptations, biochemical reactions, and genetic influences. By comprehending these intricate interactions, researchers and breeders can create resilient rice varieties that can flourish in water-limited environments. The knowledge acquired from this paper is essential for safeguarding food security during a time characterized by climate variability and escalating water shortages, rendering the development of drought-tolerant rice not only an agricultural necessity but also a crucial element of global sustainability initiatives.

Drought tolerance in rice encompasses a range of complex traits involving various physiological, biochemical, and molecular processes. Gaining insights into these mechanisms is vital for the creation of resilient rice varieties that can withstand the challenges posed by climate change and water scarcity. The following provides a comprehensive overview of the different dimensions of drought tolerance in rice.



A Detailed Overview of Drought Tolerance Mechanisms and Strategies in Rice

1. Physiological Mechanisms

- **Water Use Efficiency (WUE)**: Drought-resistant rice varieties can improve water use efficiency by increasing stomatal conductance and reducing transpiration during dry conditions. They maintain higher leaf water potential, allowing them to sustain photosynthesis for a longer time compared to more susceptible varieties.
- **Root Architecture**: Rice varieties that are resistant to drought usually have deeper and more extensive root systems, enabling them to effectively extract water from lower soil layers. Key traits that improve their drought resistance include root length density, the development of lateral roots, and the formation of aerenchyma, which are air-filled spaces within the roots.
- **Leaf Modifications**: Adaptations like leaf rolling, decreased leaf surface area, and waxy coatings assist in reducing water loss. Certain species can also change the angle of their leaves to lessen direct sunlight exposure during hot and dry conditions.

2. Biochemical Mechanisms

- **Osmotic Adjustment**: The accumulation of compatible solutes like proline, sugars, and other osmolytes helps maintain cell turgor pressure during drought conditions. These substances stabilize proteins and membranes, protecting cells from damage.
- **Antioxidant Defense**: Drought conditions result in the formation of reactive oxygen species (ROS), which can damage cells. Rice varieties that are resistant to drought usually have enhanced antioxidant systems. These systems, characterized by elevated activity levels of enzymes such as superoxide dismutase, catalase, and ascorbate peroxidase, help mitigate oxidative stress.
- **Abscisic Acid (ABA) Signaling**: ABA is a crucial plant hormone that plays a vital role in responding to drought conditions. It promotes the closure of stomata, reducing water loss, and activates the expression of genes involved in drought response.

3. Molecular Mechanisms

- **Gene Expression**: A range of genes contributes to the regulation of drought resistance. These genes include those that encode for proteins responding to stress, transcription factors, and signaling molecules. Important genes like DREB (Dehydration-Responsive Element-Binding) and NAC (NAM, ATAF, and CUC) transcription factors are crucial in how plants respond to drought conditions.

- **QTL Mapping and Marker-Assisted Selection**: Researchers have identified quantitative trait loci (QTLs) associated with drought resistance. Marker-assisted selection facilitates breeding programs by enabling early identification of plants with desirable traits.

4. Developmental Mechanisms

- **Phenological Adaptation**: Rice that can withstand drought is able to adjust its growth phases, such as the timing of flowering, to avoid dry spells. Flowering earlier enables plants to escape the most severe impacts of drought.
- **Seedling Tolerance**: Certain plants show resilience during the seedling phase, enabling them to endure temporary drought by employing strategies such as dormancy and enhanced root development.

5. Genetic Engineering and Breeding Strategies

- **Transgenic Approaches**: Genetic engineering methods have been utilized to introduce genes associated with drought resistance into rice. This process involves genes that enhance osmotic adjustment, increase antioxidant levels, and alter root structure.
- **Conventional Breeding**:Conventional breeding techniques are crucial for developing rice varieties that can endure drought. Breeders concentrate on traits such as deeper root systems, reduced transpiration rates, and improved nutrient absorption.

Conclusion

Drought tolerance in rice is a complex trait that is essential for adapting to the challenges posed by climate change and limited water availability. Understanding the detailed physiological, biochemical, and molecular processes that contribute to this tolerance is crucial for developing resilient rice varieties. Innovations in breeding methods, such as marker-assisted selection and genetic modification, hold significant promise for enhancing drought resilience in rice, helping farmers maintain yields even under challenging conditions.

As the global population continues to grow, the demand for rice will increase, making it vital to focus on developing drought-tolerant varieties in agricultural practices. By promoting collaboration among researchers, breeders, and farmers, and by investing in sustainable farming methods, we can ensure food security and protect the livelihoods of those who depend on rice. The path forward involves leveraging these scientific insights to create a more resilient agricultural future capable of withstanding the uncertainties brought about by climate fluctuations.

References

Panda, Debabrata, Swati Sakambari Mishra, and Prafulla Kumar Behera. "Drought tolerance in rice: focus on recent mechanisms and approaches." *Rice science* 28, no. 2 (2021): 119-132.

Jarin, Aysha Siddika, Md Moshiul Islam, Al Rahat, Sujat Ahmed, Pallab Ghosh, and Yoshiyuki Murata. "Drought Stress Tolerance in Rice: Physiological and Biochemical Insights." *International Journal of Plant Biology* 15, no. 3 (2024): 692-718.

Mohanavel V, Muthu V, Kambale R, Palaniswamy R, Seeli P, Ayyenar B, Rajagopalan V, Manickam S, Rajasekaran R, Rahman H, Nallathambi J, Swaminathan M, Chellappan G, Vellingiri G and Muthurajan R (2024) Marker-assisted breeding accelerates the development of multiple-stress-tolerant rice genotypes adapted to wider environments. Front. Plant Sci. 15:1402368. doi: 10.3389/fpls.2024.1402368.

Volume: 04 Issue No: 12

INTELLIGENT PACKAGING SYSTEMS: A REVOLUTION IN THE FOOD INDUSTRY IN INDIA

Article ID: AG-VO4-I12-20

Subhrajit Ojha*

University Institute of Agricultural Sciences, Chandigarh University, Gharuan, Mohali, Punjab- 140413, India

*Corresponding Author Email Id: subhrajitojha2@gmail.com

Abstract

Intelligent packaging systems in the food industry represent a transformative approach to enhancing food safety, quality, and consumer engagement. These advanced technologies integrate monitoring and sensing capabilities, smart labels, and active packaging. Sensors embedded in packaging can detect temperature, humidity, and gas variations, providing real-time data to prevent spoilage and ensure product integrity. Smart labels, including QR codes and NFC tags, facilitate traceability and offer consumers access to detailed product information, such as nutritional content and expiration dates. Active packaging systems interact dynamically with food products, either releasing preservatives or absorbing oxygen to extend shelf life and maintain freshness. These innovations not only enhance food safety and supply chain efficiency but also foster greater consumer awareness and engagement, making intelligent packaging systems a vital component of the modern food industry.

Keywords: Data Carriers, Indicators, Intelligent Packaging, RFID, Sensors

Introduction

Intelligent packaging is defined as packaging that contains an external or internal indicator to provide information about aspects of the package history and the quality of the food. The term "intelligent" is defined by the American Heritage Dictionary as "having specific data storage and processing skills" and "showing sound judgment and rationality". Intelligent packaging promises to produce safer items of higher quality (Sejani & Dhamsaniya, 2021). Using modern technology in conventional packaging helps modify the conventional form of packaging according to the end-user. The use of equipment in packaging like sensors, temperature indicators and time-temperature indicators that detect the changes that take place inside the food or any other package as time passes due to respiration activity and desiccative activity and infection by insects, microbial growth (spoilage bacteria), and by chemical changes (oxidation, change in pH value due to acidification) (Kumar *et al.,* 2021).

Intelligent Packaging Systems for Food

The intelligent packaging system is a developing technology in the food packaging sector as it senses and communicates information related to internal or external conditions and changes in packages. It has great potential to improve traceability and safety. Intelligent packaging systems are classified mainly into three groups such as sensors, indicators and data carriers.

Sensors

A sensor is a device that detects, locates or quantifies a problem before sending indications to test physical properties and chemical properties. Most sensors consist of two basic components; a receptor and a transducer. Sensors may be of several types depending on their response stimuli:

- **Biosensors:** These can detect, record and convey information relevant to biological systems. The receptors, known as bio-receptors in this case, recognize the target analyte and transducers convert these biochemical signals into measurable electrical signals. The bio-receptors may be organic or biological, like antigens, enzymes, nucleic acids, etc. The transducers used can be of an optical, acoustic or electrochemical nature. Most of the commercial biosensors are a combination of antibody-based receptors and optical transducers. Sire Technologies Inc. developed an antibody-based biosensor with the trade name Food Sentinel System where a membrane with immobilized antibodies is used as a part of the barcode which acts as the sensor (Negi *et al.*, 2019).
- **Gas sensors:** Gas sensors are employed for the detection of gaseous analytes like oxygen, water vapor, carbon dioxide, ethylene, etc. inside the package. Other than oxygen, carbon dioxide and water vapor sensors, the most used gas sensors are ethanol sensors, piezoelectric crystal sensors, semiconductor field effect transistors, and organic conducting polymers. The use of pH-sensitive dyes like methyl red and curcumin for the detection of basic volatile amine released from rotten meat and fish has been reported (Negi *et al.*, 2019).

- **Chemical sensors:** Chemical selective coatings that can adsorb a particular chemical on the surface and detect its presence, composition, activity or concentration have been employed as chemical sensors. Since carbon-based nanomaterials like graphene, carbon nanotubes and carbon nanofibers have excellent electrical and mechanical properties as well as exceptional surface area, they have been widely applied as chemical sensors. These nano-based sensors are used for the detection of chemical contaminants, pathogens and spoilage as well as for the tracking of products or ingredients through the processing chain (Negi *et al.*, 2019).
- **Electronic Nose:** Instruments have been designed to identify and classify the mixture of aromas in an odour on a repeatable basis a function like that of the mammalian olfactory system. The instrument is composed of an array of sensors, either chemical sensors or biosensors, which show partial specificity to each kind of odour. The statistical methods are used to recognize simple and complex odour and produce a unique response towards each one. Successful testing of the electronic nose system has been carried out in response to the odour released by fresh yellowfin tuna, vacuum-packed beef, fruits and vegetables, and broiler chicken (Negi *et al.*, 2019).

Indicators

These are substances that can determine the presence or concentration of other substances, or the reaction between two or more substances, by giving characteristic optical changes like colour change (Negi *et al.*, 2019).

- **Time-Temperature Indicator:** It is a simple and inexpensive device as compared to other indicators that can show an easily detectable, time-temperature-dependent change that determines the full or partial history of the temperature of a food product to which it is attached (Sejani & Dhamsaniya, 2021). An indicator such as Fresh-Check manufactured by Lifeline Technologies is an example of a time-temperature indicator (Kumar *et al.*, 2021).
- **Gas indicators:** After packing food in packaging material, atmospheric change has occurred due to the respiration of food, microbial spoilage, or gas leakage through the packaging film from the surrounding air. Gas indicators can monitor the changes in gas composition inside the package and thus can help monitor the product quality. Gas indicators can be used in controlled or modified atmosphere packaging (MAP). In MAP,

gas indicators monitor the atmospheric condition by direct contact with the packaging atmosphere. These indicate the change in the gaseous atmosphere and will provide the information through indicator by changing its colour. The presence of oxygen is the most common reason for food spoilage (Sejani & Dhamsaniya, 2021).

- **Freshness Indicators:** These are very useful for food manufacturers, retailers as well as final consumers. A freshness indicator provides quick information about the quality of a product. Using microbial growth metabolites, which reveal changes occurring within the food, rather than simply suggesting temperature abuse or package leakage (Sejani & Dhamsaniya, 2021). Ripe Sense TM, an indicator, is commercially available for measurement of the freshness of fruits and vegetables. It uses a mark that interacts with the chemical aromatic (benzene derivatives) compounds along with ethylene gas released during the process of ripening food products during transportation or storing in the warehouse to show the ripeness of the fruit (Kumar *et al.*, 2021).
- **Integrity Indicators:** Leakage prevention is an important aspect to be considered throughout the production and distribution chain of packaged food. Integrity indicators function to ensure their integrity. Visual oxygen indicators are composed of redox-sensitive dyes that change color with the change in oxygen concentration in MAP foods. Mitsubishi Gas Chemical Company developed oxygen indicator tablets by trade name Ageless Eye which turn pink when oxygen concentration is less than 0.01% and turn blue when it goes beyond 0.5%. The presence of oxygen will be indicated in five minutes or less, while the change from blue to pink may take three hours or more (Negi *et al.*, 2019).

Data Carriers

Data carrier kind of electronic devices are incorporated in packaging which provides various advantages like better traceability and trackability for inventory management in the supply chain. Data carriers are called automatic recognition equipment (Kumar *et al.*, 2021).

- **Barcodes:** Stores data in the form of one-dimensional array spaces and parallel lines. These can be scanned or read by optical scanners and smartphones (Kumar *et al.*, 2021).
- **Quick Response (QR) Codes:** Quick response codes are a two-dimensional array of randomly arranged dots and rectangles. QR codes like bar codes can be used on primary, secondary and tertiary packaging holding needful information. The invention of bar codes was done by DENSO WAVE Japan-based Company, in 1994 (Kumar *et al.*, 2021).

- **Near Field Communication (NFC) Tags:** Information Communication and Technology solutions affect the value and safety of any product, and they are needed to maximize the flow of information between farmers and stakeholders, as well as to enhance traceability in the food supply chain. Tracking of food and packages throughout the supply chain is very good and important for consumers and inventory managers to be safe from a scam (Kumar *et al.*, 2021).

Radio Frequency Identification Device (RFID)

RFID is not a sensor or an indicator but rather a wireless data-gathering system that uses electronic tags to store and identify data. Tags are attached to communicate data to a reader. It has been used for tracking expensive items since the 1980s. In 2005, Walmart was the first supply chain to introduce the RFID system. RFID is the most advanced technology as compared to manual systems or barcodes because it is more accurate and can be read without the need for visual contact. Tags are classified into two categories; passive tags which are cheap, simple, short-range and powered by energy from the reader and active tags which are battery-powered, longer longer-range and collect more information (nutritional information, temperature, cooking instructions, etc.) (Negi *et al.*, 2019).

Conclusion

Intelligent packaging is a modern and successful technique that has boosted the marketing ability of the product in recent years. These technologies, when integrated with the food packages can prove to be useful not only for the extension of food shelf life while improving quality, but also can provide useful information regarding the product. More intensive research is still required in intelligent packaging material to develop more economical systems while offering convenience to the consumer.

References

Kumar, J., Akhila, K., & Gaikwad, K. K. (2021). Recent Developments in Intelligent Packaging Systems for Food Processing Industry: A Review. *Journal of Food Processing and Technology*, 12(7): 895.

Negi, Y. S., Priyadarshi, R., & Kulshreshta, A. (2019). Intelligent Packaging Systems for Food Applications. Available via 360 Packaging. https://packaging360.in/insights/intelligent-packaging-systems-for-food/

Sejani, V. M., & Dhamsaniya, N. K. (2021). Intelligent Packaging for Food: A Review. *Chemical Science Review and Letters*, 10(40): 466-477.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

Article ID: AG-VO4-I12-21

CLINICAL UPDATE ON FELINE INFECTIOUS PERITONITIS (FIP)

Vikram Chandu V* and Gidla Srinivas

*Undergraduate Student, Rajiv Gandhi Institute of Veterinary Education & Research, Pondicherry University, U. T of Pondicherry, India

*Corresponding Author Email ID: vikramchanduvemulapalli00@gmail.com

Introduction

Feline Corona Virus (FCoV) is a contagious enteric pathogen, it primarily causes self-limiting, mild or asymptomatic enteric infection in cats (Dunbar, D *et al*., 2024), but in few cases (about 5%) these viruses mutate in infected cats and produces immune mediated disease termed as Feline Infectious Peritonitis (FIP). Feline coronavirus manifests in 2 forms: the low-virulence feline enteric coronavirus (FECV) and the high-virulence FIP virus (FIPV) (Harry Vennema *et al*., 1998). There is considerable evidence, but no absolute proof, that enteric coronaviruses mutate and thereby develop the pathologic and invasive characteristics that are associated with in feline infectious peritonitis virus (Frederick A. Murphy *et al*., 1999). FIP commonly occurs in cats originating from catteries, shelters and foster/rescue groups, as the prevalence of feline coronavirus (FCoV) infection is high in cats living in crowded conditions (Klein-Richers U *et al*., 2020).

FIPV is an Alpha coronavirus 1, non- contagious (though FCoV is contagious) and highly infectious disease. It has been estimated that around 0.3% to 1.4% of feline deaths at veterinary institutions are caused by FIP (Thayer V *et al*., 2022). Cases of FIP are generally noticed in younger cats less than 2 years of age. According to Pesteanu-Somogyi LD *et al*., 2005, Certain breeds may in fact be more likely to develop FIP, particularly the Birman, Ragdoll, Bengal, Rex, Abyssinian, and Himalayan breeds.

Types: mainly 3 forms, effusive or wet form, non-effusive or dry form, mixed form.

1. **Wet form**: most common form characterised by pleural, abdominal & pericardial effusions (due to pleuritis, peritonitis, pericarditis respectively). Due to severe immune mediated vascular damage (& vasculitis) there is fluid leakage into body cavities.
2. **Dry form:** no fluid accumulation but severe perivascular pyo-granulomatous inflammation in multiple organs (liver, spleen, brain, kidney, pancreas, eyes etc.) is noticed, this form progresses slowly compared to wet form. Based on location of lesions & tissues involved sub-types include neurological FIP, ocular FIP, renal FIP, pancreatic FIP, hepatic FIP etc.
    - **Neurological FIP**: due to granulomatous inflammation in CNS (encephalitis, sometimes meningitis). Neurological clinical signs in cats with FIP are reflective of the neuroanatomic location of the primary lesions. Multifocal clinical signs are common, though focal signs may also be found (Diaz JV *et al*.,2009).
    - **Ocular FIP**: many cats with FIP has ocular lesions mainly showing uveitis, ocular pain, altered light sensitivity, squinting, even blindness.
3. **Mixed form**: occasionally occurs, combination of both dry and wet forms. In some cases of non-effusive FIP, body effusion can develop at the terminal stage of the disease and become a mixed-type of FIP upon necropsy (Tsai HY *et al*., 2009).

Clinical signs

In earlier stages signs are usually uncertain, infected cat has intermittent fever, decreased activity, lethargy, unthriftiness, depression, hyporexia or anorexia, weight loss, poor growth, anaemia. The disease progression may take days to months. In later stages the cat shows

Wet form: due to the progressive fluid build-up in abdomen, ascites or pot belly appearance can be observed. Effusion in thorax causes severe dyspnoea, tachypnoea & cyanosis, muffled heart sounds (in pericardial effusion), scrotal swelling in few cats.

Dry form: signs are usually non-specific & varies based on the organs involved,

- In neurological FIP, cat shows unsteady gait, ataxia, hyperesthesia, seizures, behavioural changes, paralysis, tetraparesis, nystagmus etc. Hydrocephalus can occur in some patients.
- FIP with ocular involvement, signs like hyphema, pupillary changes, anisocoria, keratic precipitates deposition, anterior uveitis, corneal oedema, hypopyon, rubeosis iridis, severe retinal damage, chorioretinitis and blindness will be noticed.

- Cats with abdominal granulomas has severe organ dysfunction like constipation to obstipation (due to G.I masses). Severe scrotal enlargement, icterus and hepatomegaly, intestinal pyogranulomatous mass, splenomegaly, pancreatitis, mesenteric lymphadenopathy, omental adhesions and mass (Sherding RG, 2006) are noticed in many patients. Protein loosing enteropathy can be seen in cases with intestinal involvement.
- Some may develop dermopathy (cutaneous papules, dermal vasculitis etc.), In few cases transition between forms may occur or mixed form with clinical signs of both types can occur.

Diagnosis

When pursuing a diagnosis of FIP, the same or different test modalities can be performed on a variety of sample types, including blood (whole blood, serum, plasma, peripheral blood mononuclear cells [PBMCs]), effusions (thoracic, abdominal, pericardial), tissues, cerebrospinal fluid (CSF), aqueous humour, and/or tissue fine-needle aspirates (FNAs) and biopsies (Thayer V *et al*., 2022).

Tentatively diagnosis can be arrived based on history (progressive illness and loss of conditions, non-antibiotic responsive pyrexia), clinical signs (but unreliable, because of no FIP specific signs), confirmation is only done after performing multiple tests (due to variability in specificity and sensitivity). An ideal test should work on different fluids, such as serum and effusion, have high sensitivity and specificity, should allow the use of small sample quantities, provide a quantitative value and a rapid result (Felten S *et al*., 2019).

Haematological & Serum biochemical changes:

Cronic non – regenerative anaemia, low PCV, low haemoglobin levels, leucocytosis, neutrophilia (shift to left), lymphopenia, hyperglobulinemia, hypoalbuminemia, low albumin to globulin ration (A: G, mostly below 0.4), hyperproteinaemia has been documented in cats with FIP, but more commonly in the non-effusion form (Moyadee W *et al*., 2023), hyperbilirubinemia, liver enzymes level elevation etc. Serum protein electrophoresis characterized by increased α2 and γ-globulin (polyclonal peak) (Romanelli P *et al*., 2024), There is severe rise in plasma alpha1-glycoprotein (AGP) and plasma vascular endothelial growth factor (VEGF) concentration levels in FIP infected cats (Doki T *et al.*, 2016).

In effusive form, the typical fluid from a cat with FIP is viscous, straw-coloured, clear to moderately cloudy and usually forms clots or strings because of its high protein content (Niels C

Pedersen, 2014). Evaluation of protein content yields a total protein > 3.5 gm/dl, over 50% of which is composed of gamma globulins. Cytology of the fluid reveals an exudate with cellularity (< 5000 cells/µl) consisting primarily of non-degenerative neutrophils. (Berry ML, 2001). Other causes of pot belly should be ruled out, refractometer can be used for estimation of specific gravity and total protein (TP) concentration in effusion.

Rivalta test: The test involves placing a few drops of ascites or thoracic fluid into a tube containing a weak acetic acid solution. The appearance of a white flocculent material is seen in a positive test. A positive Rivalta test was once believed to be highly specific for FIP fluid (Niels C. Pedersen *et al*., 2014). According to study by Fischer Y *et al*., 2012, The Rivalta test had a sensitivity of 91.3%, specificity of 65.5%, PPV of 58.4%, and NPV of 93.4% for the diagnosis of FIP.

Histopathology: Histopathological examination is performed on necropsy or biopsy samples (by ultrasound guided FNAC or other minimal invasive biopsy procedures). On microscopy severe vasculitis, perivascular infiltration, pyogranulomatous changes, nodular inflammatory (& leucocyte) infiltration with extensive cellular damage can be noticed.

Post-mortem examination: Gross lesions - In wet form, there is extensive fibrinous plaque with numerous discrete grey-white nodules (from <1 to >10 mm in diameter) in the omentum and on the serosal surface of the liver, spleen, intestines, and kidneys (Fenner's Veterinary Virology, 2017) and in dry form pyo-granulomatous masses on multiple organs observed.

Diagnostic imaging: Chest and abdominal x-rays reveals presence of effusion, organomegaly & extensive organ damage. In abdominal ultrasonography; ascitic fluid, granulomas on organs (correlated with mass felt on abdominal palpation), change in tissue echogenicity are noticed. CT and MRI scans are helpful to locate granulomatous masses, fluid build-up in tissues & cavities, in neuronal involvement cases for ventricles enlargement, lesions in intra-parenchymal regions etc.

CSF examination: Typical CSF findings in cats with FIP were a protein concentration of greater than 2 g/L (200 mg/dL) and a white cell count of over 100 cells/microL, which consisted predominantly of neutrophils (Rand JS *et al*., 1994).

Immunological & Serological tests:

FCoV antibody testing - Anti-feline coronavirus (FCoV) antibody test, CSF titre of 1:640 or higher may be served as a candidate for the index for diagnosing FIP (Soma T *et al*., 2018).

Commercial in-practice FCoV antibody test is performed using serum, plasma or ascitic fluid. The sensitivity of the in-practice test was 95% and the specificity was 83%. All positive results obtained using the in-practice kit should be confirmed and titrated by IFA (Addie DD *et al*., 2004).

PCR - RT-PCR for Feline enteric coronavirus can be tested in faeces of younger cats before introducing into places where multiple cats are residing, it is practiced for early isolation, to prevent shedding and infecting other cats. This test also can be formed for cats suspected with FIP, on fresh tissues, ascitic fluid, whole blood, serum or plasma samples. mRNA RT-PCR has low rate of false-positive results (high specificity) this test may be a valuable addition to the diagnostic arsenal for FIP (Simons FA *et al*., 2004).

Immunostaining methods - Immuno-histological staining of biopsy and necropsy samples are usually considered as standard methods in diagnosing FIP. FIP confirmed either by histopathology alone or in combination with immunohistochemistry (IHC) of tissue samples, IHC can also been applied to detect FCoV antigen in macrophages in unusual tissues or non-domestic felids (Felten S *et al*., 2019).

Anti-FCoV immuno-histochemistry (IHC) is mandatory to confirm/exclude the disease in doubtful cases (Hartmann K, 2005). Direct immunofluorescence (DIF) testing to detect feline coronavirus in macrophages in effusion specimens has been reported to have 100% specificity (Litster AL *et al*., 2013), considered as gold standard. Other tests to detect FIP include ELISA, virus neutralization assay and rapid immuno-chromatographic test etc.

Differential diagnosis: Toxoplasmosis, Lymphocytic cholangitis, Neoplasia (eg, lymphoma, abdominal carcinoma), Pancreatitis, Retroviral infection, Mycobacterial infection including tuberculosis (TB), Pyothorax, Sepsis, Septic peritonitis, Congestive heart failure, Rabies (Tasker S, 2018). also should rule out other causes of ascites, neurological signs and ocular lesions.

Co-morbidities: Feline infectious peritonitis often occurs in association with other diseases, particularly those likely to cause immunosuppression, such as feline leukemia, feline pan leukopenia, and feline syncytial virus infections (Frank Fenner *et al*., 1987).

Prognosis: The prognosis depends upon duration of infection, co-morbidities, involvement of organs & extent of internal damage. It is poor when misdiagnosed or without any treatment. Cats with wet form of FIP has less survival time compared to dry form. Cats with neurological involvement has poor prognosis.

Treatment

Specific antiviral therapy - The use of antivirals in treatment of FIP is rapidly growing and the common drugs (used alone or in combination) include Remdesivir, GS-441524, GC376, Molnupiravir.

Table 4 Nucleoside analogue treatment data for cats with feline infectious peritonitis, including response and follow-up, according to treatment group

Treatment protocol	Number of cats with indicated treatment/total number of cats (%)	Median (range) starting dose (mg/kg)	Median (range) duration of initial treatment period (days)	Number of cats with a complete response at end of initial treatment period* (%)	Number of cats alive or dead at end of initial treatment period (%)	Number of cats alive or dead at longest follow-up time point after starting initial treatment period (%)	Median (range) longest follow-up time point after starting initial treatment period (days)
Remdesivir alone	104/307 (33.9)	10 (5–20)	84 (1–162)	73/104 (70.2)	Alive: 76/104 (73.1) Dead: 28/104 (26.9)	Alive: 67/104 (64.4) Dead: 37/104 (35.6)	358 (1–814)
Remdesivir then GS-441524	171/307 (55.7)	10 (5–27) 12 (5–27)	Duration of remdesivir then GS-441524 treatment 84 (12–330), with initial remdesivir of 14 (1–240) then GS-441524 of 70 (2–120)	156/171 (91.2)	Alive: 166/171 (97.1) Dead: 5/171 (2.9)	Alive: 162/171 (94.7) Dead: 9/171 (5.3)	248 (12–684)
GS-441524 alone	32/307 (10.4)	12.9 (8.3–20)	84 (7–91)	30/32 (93.8)	Alive: 30/32 (93.8) Dead: 2/32 (6.3)	Alive: 30/32 (93.8) Dead: 2/32 (6.3)	181 (7–444)
All treatment protocols combined	307 (100)	10 (5–27)	84 (1–330)	259/307 (84.4)	Alive: 272/307 (88.6) Dead: 35/307 (11.4)	Alive: 259/307 (84.4) Dead: 48/307 (15.6)	248 (1–814)

*Initial treatment period is the first period of continuous treatment with nucleoside analogues. For discussion on changing dose recommendations occurring during the course of the study, please refer to the text

Table reference: Taylor SS *et al*., 2023, Journal of Feline Medicine and Surgery. 2023;25(9). Doi:10.1177/1098612X231194460.

- GC376; it is a protease inhibitor, prodrug of GC373 (which is also a protease inhibitor) (Sharun K *et al*., 2020). GC376 can be administered subcutaneously (SC) at a dosage of 15 mg/kg q12h SC, minimum of 12 weeks (Pedersen NC *et al*., 2018).
- Molnupiravir might be an effective and safe treatment for domestic cats with FIP at a dose of 10-20 mg/kg twice daily for duration of 84 days (Sase O, 2023).
- Use of EIDD-1931, an active metabolite of Molnupiravir also documented in FIP cases.
- Ribavirin of 16.5 mg/kg for 24 h for 10–14 days orally, intramuscularly, or intravenously (Weiss R.C *et al*., 1993), but the use of ribavirin for FIP is limited.

Non-antiviral therapy

a) **Antimalarial drugs -** Mefloquine which is an adenosine analogue, human antimalarial drug, can be administered orally at 62.5 mg (10–12 mg/kg) twice weekly (Yu J *et al*., 2020). Other antimalarial drugs include Chloroquine, hydroxychloroquine also has inhibitory effect on virus

b) **Immuno-suppressive drugs -** Cyclosporin A (CsA), an immunosuppressive agent that targets the nuclear factor pathway of activated T-cells (NF-AT) to bind cellular cyclophilins (CyP), dose-dependently inhibited FIPV replication in vitro (Tanaka Y *et al*., 2012). 75 mg/day of modified cyclosporin A is used by Tanaka, Y *et al*., 2015. Other immuno-suppressive drugs which can slow the disease progression, like Cyclophosphamine (4 mg/kg q 24 h), prednisolone can be used for 6 weeks (Hartmann K *et al*., 2008 & Bilkei G, 1988).

c) Itraconazole (ICZ), a triazole antifungal agent (De Beule K *et al*., 2001), according to study by Kameshima S *et al*., 2020, there is severe decrease in the accumulation of pleural fluid, and an increase in the A/G ratio. In addition, the fecal FCoV levels temporarily decreased with the combination therapy of ICZ (10 mg/kg q12 hr) and Prednisolone (1 mg/kg q24 hr) in the treatment of a cat with spontaneous FIP.

d) **Replication inhibitors**: Hexamethylene amiloride (HMA), a viroporin inhibitor, can inhibit the ion channel activity of the E protein and replication of several coronaviruses (Takano T *et al*., 2015). Triple Helix Forming Oligonucleotides (antiviral activity) & Small interfering RNAs also have inhibitory effect on virus replication.

Other protocols

- Low-dose human interferon-α (10 IU/Kg), with treatment there is rapid regression of overt immunopathological conditions in virus-infected cats (E. Pedretti *et al*., 2006).
- Polyprenyl Immunostimulant™ (PI), which enhances cell-mediated immunity by upregulating the innate immune response via Toll-like receptors, is a rational approach with the dosage of 3 mg/kg three times a week or 3 mg/kg every other day administered orally (Petra Černá *et al*., 2022).
- Thromboxane synthetase inhibitor (Ozagrel HCl, 5 mg/kg, twice a day) can be used in cats (Tae-Sin Kim *et al*., 2010), shows good clinical improvement.
- Anti-feline TNF-alpha mAb is effective for the treatment of FIP in vivo (Doki T *et al*., 2016).

The use of these drugs are quite limited due to non-availability, varied efficacy, cost, lack of extensive scientific research & data

Ancillary therapy - To alleviate clinical signs, for aiding in recovery and increase in quality of life.

- Thoracentesis and abdominocentesis to relieve discomfort and dyspnoea (re-accumulation can occur rapidly).
- Diuretics can be used to remove excess fluid accumulated (like furosemide, spironolactone etc.) with careful monitoring of serum mineral values.
- Anti-seizure medication and nerve supportives in neurological FIP
- Pericardiocentesis if required, oxygen therapy in severe dyspnoea cases.
- Ocular FIP should be managed with topical (ocular) medications like anti-inflammatory, steroids, antibiotics (to prevent secondary bacterial infection).
- Omega 3 fatty acids supplementation
- Vitamin B12 supplementation (aids in RBC production, boosting immune system, for nerve health),
- Drugs to counter the side effects & toxicity of specific antiviral and non- antiviral therapies like anti-emetics, appetite stimulants, liver and renal supportives (if required).
- If cats are stabilised & responding to the treatment well, neutering can be performed to prevent breeding stress.
- Nutritional support and providing balanced diet is necessary.
- Fluid therapy (if required), with caution and under strict monitoring.

Conclusion

Due to varied clinical signs, diagnosing FIP is quite challenging and in many cases misdiagnosis or under-diagnosis can happen. Once the cat is positive for FIP, it requires continuous monitoring and repetitive analysis on improvement in clinical signs. Currently available treatment protocols can extend the quality of life but in severe cases and treatment non-responsive cases (for cat's welfare) euthanasia should be performed with owner's consent.

Referenes

Addie DD, McLachlan SA, Golder M, Ramsey I, Jarrett O. Evaluation of an in-practice test for feline coronavirus antibodies. J Feline Med Surg. 2004 Apr;6(2):63-7. Doi: 10.1016/j.jfms.2004.01.001. PMID: 15123150; PMCID: PMC7128989.

Berry ML. FELINE INFECTIOUS PERITONITIS. Feline Internal Medicine Secrets. 2001:175–80. Doi: 10.1016/B978-1-56053-461-7.50042-5. Epub 2009 May 15. PMCID: PMC7152141.

Bilkei G. Beitrag zur Therapie der FIP. Tierarztl. Umsch. 1988;43:192–196.

Černá P, Ayoob A, Baylor C, Champagne E, Hazanow S, Heidel RE, Wirth K, Legendre AM, Gunn-Moore DA. Retrospective Survival Analysis of Cats with Feline Infectious Peritonitis Treated with Polyprenyl Immunostimulant That Survived over 365 Days. Pathogens. 2022 Aug 4;11(8):881. Doi: 10.3390/pathogens11080881. PMID: 36015002; PMCID: PMC9414324.

Diaz JV, Poma R. Diagnosis and clinical signs of feline infectious peritonitis in the central nervous system. Can Vet J. 2009 Oct;50(10):1091-3. PMID: 20046611; PMCID: PMC2748294.

De Beule K., Van Gestel J.2001. Pharmacology of itraconazole. Drugs 61 Suppl 1: 27–37. Doi: 10.2165/00003495-200161001-00003.

Doki T, Takano T, Kawagoe K, Kito A, Hohdatsu T. Therapeutic effect of anti-feline TNF-alpha monoclonal antibody for feline infectious peritonitis. Res Vet Sci. 2016 Feb;104:17-23. Doi: 10.1016/j.rvsc.2015.11.005. Epub 2015 Nov 12. PMID: 26850532; PMCID: PMC7111801.

Dunbar, D., Babayan, S.A., Krumrie, S. Et al. Assessing the feasibility of applying machine learning to diagnosing non-effusive feline infectious peritonitis. Sci Rep 14, 2517 (2024). https://doi.org/10.1038/s41598-024-52577-4.

E. Pedretti, B. Passeri, M. Amadori, P. Isola, P. Di Pede, A. Telera, R. Vescovini, F. Quintavalla, M. Pistello, Low-dose interferon-α treatment for feline immunodeficiency virus infection, Veterinary Immunology and Immunopathology, Volume 109, Issues 3-4, 2006, Pages 245-254, ISSN 0165-2427, https://doi.org/10.1016/j.vetimm.2005.08.020. (https://www.sciencedirect.com/science/article/pii/S0165242705002643).

Felten S, Hartmann K. Diagnosis of Feline Infectious Peritonitis: A Review of the Current Literature. Viruses. 2019 Nov 15;11(11):1068. Doi: 10.3390/v11111068. PMID: 31731711; PMCID: PMC6893704.

Fenner's Veterinary Virology (Fifth Edition), Chapter 24 – Coronaviridae, Editor(s): N. James MacLachlan, Edward J. Dubovi, Academic Press, 2017, Pages 435-461, ISBN

9780128009468, https://doi.org/10.1016/B978-0-12-800946-8.00024-6. (https://www.sciencedirect.com/science/article/pii/B9780128009468000246).

Fischer Y, Sauter-Louis C, Hartmann K. Diagnostic accuracy of the Rivalta test for feline infectious peritonitis. Vet Clin Pathol. 2012 Dec;41(4):558-67. Doi: 10.1111/j.1939-165X.2012.00464.x. Epub 2012 Aug 22. PMID: 22913882; PMCID: PMC7169324.

Frank Fenner, Peter A. Bachmann, E. Paul J. Gibbs, Frederick A. Murphy, Michael J. Studdert, David O. White, CHAPTER 28 – Coronaviridae, Editor(s): Frank Fenner, Peter A. Bachmann, E. Paul J. Gibbs, Frederick A. Murphy, Michael J. Studdert, David O. White, Veterinary Virology, Academic Press, 1987, Pages 505-518, ISBN 9780122530555, https://doi.org/10.1016/B978-0-12-253055-5.50032-3. (https://www.sciencedirect.com/science/article/pii/B9780122530555500323).

Frederick A. Murphy, E. Paul J. Gibbs, Marian C. Horzinek and Michael J. Studdert. Veterinary Virology, Third Edition, Academic Press, 1999, Pathogenesis of Viral Diseases: Representative Model Diseases, page – 171.

Hartmann K. Feline infectious peritonitis. Vet Clin North Am Small Anim Pract. 2005 Jan;35(1):39-79, vi. Doi: 10.1016/j.cvsm.2004.10.011. PMID: 15627627; PMCID: PMC7114919.

Hartmann K, Ritz S. Treatment of cats with feline infectious peritonitis. Vet Immunol Immunopathol. 2008 May 15;123(1-2):172-5. Doi: 10.1016/j.vetimm.2008.01.026. Epub 2008 Jan 19. PMID: 18395801; PMCID: PMC7132371.

Harry Vennema, Amy Poland, Janet Foley, Niels C. Pedersen, Feline Infectious Peritonitis Viruses Arise by Mutation from Endemic Feline Enteric Coronaviruses, Virology, Volume 243, Issue 1, 1998, Pages 150-157, ISSN 0042-6822, https://doi.org/10.1006/viro.1998.9045. (https://www.sciencedirect.com/science/article/pii/S0042682298990456).

Kameshima S, Kimura Y, Doki T, Takano T, Park CH, Itoh N. Clinical efficacy of combination therapy of itraconazole and prednisolone for treating effusive feline infectious peritonitis. J Vet Med Sci. 2020 Oct 20;82(10):1492-1496. Doi: 10.1292/jvms.20-0049. Epub 2020 Aug 27. PMID: 32848107; PMCID: PMC7653327.

Klein-Richers U, Hartmann K, Hofmann-Lehmann R, et al. Prevalence of feline coronavirus shedding in German catteries and associated risk factors. Viruses 2020; 12: 1000–1013.

Litster AL, Pogranichniy R, Lin TL. Diagnostic utility of a direct immunofluorescence test to detect feline coronavirus antigen in macrophages in effusive feline infectious peritonitis. Vet J. 2013 Nov;198(2):362-6. Doi: 10.1016/j.tvjl.2013.08.023. Epub 2013 Sep 4. PMID: 24076123; PMCID: PMC7110874.

Moyadee W, Chiteafea N, Tuanthap S, Choowongkomon K, Roytrakul S, Rungsuriyawiboon O, Boonkaewwan C, Tansakul N, Rattanasrisomporn A, and Rattanasrisomporn J (2023) The first study on clinicopathological changes in cats with feline infectious peritonitis with and without retrovirus coinfection, Veterinary World, 16(4): 820–827.

Niels C. Pedersen, An update on feline infectious peritonitis: Diagnostics and therapeutics, The Veterinary Journal, Volume 201, Issue 2, 2014, Pages 133-141, ISSN 1090-0233, https://doi.org/10.1016/j.tvjl.2014.04.016. (https://www.sciencedirect.com/science/article/pii/S1090023314001774).

Pedersen NC. An update on feline infectious peritonitis: diagnostics and therapeutics. Vet J. 2014 Aug;201(2):133-41. Doi: 10.1016/j.tvjl.2014.04.016. Epub 2014 May 2. PMID: 24857253; PMCID: PMC7110619.

Pedersen NC, Kim Y, Liu H, Galasiti Kankanamalage AC, Eckstrand C, Groutas WC, Bannasch M, Meadows JM, Chang KO. Efficacy of a 3C-like protease inhibitor in treating various forms of acquired feline infectious peritonitis. J Feline Med Surg. 2018 Apr;20(4):378-392. Doi: 10.1177/1098612X17729626. Epub 2017 Sep 13. PMID: 28901812; PMCID: PMC5871025.

Pesteanu-Somogyi LD, Radzai C, Pressler BM. Prevalence of feline infectious peritonitis in specific cat breeds. J Feline Med Surg. 2006 Feb;8(1):1-5. Doi: 10.1016/j.jfms.2005.04.003. Epub 2005 Jul 1. PMID: 15994104; PMCID: PMC7128820.

Rand JS, Parent J, Percy D, Jacobs R. Clinical, cerebrospinal fluid, and histological data from twenty-seven cats with primary inflammatory disease of the central nervous system. Can Vet J. 1994 Feb;35(2):103-10. PMID: 8069819; PMCID: PMC1686724.

Romanelli P, Bertazzolo W, Prisciandaro A, Leone A, Bonfanti U, Paltrinieri S. Measurement of Feline Alpha-1 Acid Glycoprotein in Serum and Effusion Using an ELISA Method: Analytical Validation and Diagnostic Role for Feline Infectious Peritonitis. Pathogens. 2024 Mar 29;13(4):289. Doi: 10.3390/pathogens13040289. PMID: 38668244; PMCID: PMC11055121.

Sase O. Molnupiravir treatment of 18 cats with feline infectious peritonitis: A case series. J Vet Intern Med. 2023 Sep-Oct;37(5):1876-1880. Doi: 10.1111/jvim.16832. Epub 2023 Aug 8. PMID: 37551843; PMCID: PMC10472991.

Sharun K, Tiwari R, Dhama K. Protease inhibitor GC376 for COVID-19: Lessons learned from feline infectious peritonitis. Ann Med Surg (Lond). 2020 Dec 28;61:122-125. Doi: 10.1016/j.amsu.2020.12.030. PMID: 33456770; PMCID: PMC7797473.

Sherding RG. Feline Infectious Peritonitis (Feline Coronavirus). Saunders Manual of Small Animal Practice. 2006:132–43. Doi: 10.1016/B0-72-160422-6/50012-7. Epub 2009 May 15. PMCID: PMC7150141.

Simons FA, Vennema H, Rofina JE, Pol JM, Horzinek MC, Rottier PJ, Egberink HF. A mRNA PCR for the diagnosis of feline infectious peritonitis. J Virol Methods. 2005 Mar;124(1-2):111-6. Doi: 10.1016/j.jviromet.2004.11.012. Epub 2004 Dec 21. PMID: 15664058; PMCID: PMC7112896.

Soma T, Saito N, Kawaguchi M, Sasai K. Feline coronavirus antibody titer in cerebrospinal fluid from cats with neurological signs. J Vet Med Sci. 2018 Jan 1;80(1):59-62. Doi: 10.1292/jvms.17-0399. Epub 2017 Nov 9. PMID: 29118313; PMCID: PMC5797860.

Tae-Sin Kim, Sun-Hee Lee, Soo-Jung Lim, Hyung-Jin Park, Eun-Sik Song, Dae-Wook Jung, Duck-Hwan Kim, Kun-Ho Song, Application of thromboxane synthetase inhibitor (Ozagrel HCl) in feline infectious peritonitis. Korean J Vet Res. 2010;50(1):63-69.

Takano T, Nakano K, Doki T, Hohdatsu T. Differential effects of viroporin inhibitors against feline infectious peritonitis virus serotypes I and II. Arch Virol. 2015 May;160(5):1163-70. Doi: 10.1007/s00705-015-2370-x. Epub 2015 Feb 21. PMID: 25701212; PMCID: PMC7086594.

Tanaka Y, Sato Y, Osawa S, Inoue M, Tanaka S, Sasaki T. Suppression of feline coronavirus replication in vitro by cyclosporin A. Vet Res. 2012 Apr 30;43(1):41. Doi: 10.1186/1297-9716-43-41. PMID: 22546085; PMCID: PMC3403912.

Tanaka, Y., Sato, Y., Takahashi, D., Matsumoto, H. And Sasaki, T. (2015), Treatment of a case of feline infectious peritonitis with cyclosporin A. Vet Rec Case Rep, 3: e000134. https://doi.org/10.1136/vetreccr-2014-000134.

Tasker S. Diagnosis of feline infectious peritonitis: Update on evidence supporting available tests. Journal of Feline Medicine and Surgery. 2018;20(3):228-243. Doi:10.1177/1098612X18758592.

Tasker S, Dowgray N. Managing feline coronavirus and feline infectious peritonitis in the multi-cat/shelter environment. In: Dean R, Roberts M, Stavisky J (eds). BSAVA manual of canine and feline shelter medicine: principles of health and welfare in a multi-animal environment. Gloucester: BSAVA Publications. In press, 2018.

Thayer V, Gogolski S, Felten S, Hartmann K, Kennedy M, Olah GA. 2022 AAFP/EveryCat Feline Infectious Peritonitis Diagnosis Guidelines. Journal of Feline Medicine and Surgery. 2022;24(9):905-933. Doi:10.1177/1098612X221118761.

Tsai HY, Chueh LL, Lin CN, Su BL. Clinicopathological findings and disease staging of feline infectious peritonitis: 51 cases from 2003 to 2009 in Taiwan. J Feline Med Surg. 2011 Feb;13(2):74-80. Doi: 10.1016/j.jfms.2010.09.014. Epub 2011 Jan 8. PMID: 21216644; PMCID: PMC7129202.

Weiss R.C., Cox N.R., Martinez M.L. Evaluation of free or liposome-encapsulated ribavirin for antiviral therapy of experimentally induced feline infectious peritonitis. Res. Vet. Sci. 1993;55:162–172. Doi: 10.1016/0034-5288(93)90076-R.

Yu J, Kimble B, Norris JM, Govendir M. Pharmacokinetic Profile of Oral Administration of Mefloquine to Clinically Normal Cats: A Preliminary In-Vivo Study of a Potential Treatment for Feline Infectious Peritonitis (FIP). Animals (Basel). 2020 Jun 8;10(6):1000. Doi: 10.3390/ani10061000. PMID: 32521771; PMCID: PMC7341284.

Table reference -

Taylor SS, Coggins S, Barker EN, et al. Retrospective study and outcome of 307 cats with feline infectious peritonitis treated with legally sourced veterinary compounded preparations of remdesivir and GS-441524 (2020–2022). Journal of Feline Medicine and Surgery. 2023;25(9). Doi:10.1177/1098612X231194460. Copyright © 2023, Sage Publications.

Volume: 04 Issue No: 12

TREE MULBERRY PLANTATION

Article ID: AG-VO4-I12-22

[1]*A.Thangamalar, [2]P.Priyadharshini and [3]K.Indirakumar

1 Teaching Assistant (Sericulture), Department of Sericulture, Forest College & Research Institute, Tamil Nadu Agricultural University, Mettupalayam, Tamil Nadu, India

2 Assistant Professor (Sericulture), Department of Sericulture, Forest College & Research Institute, Tamil Nadu Agricultural University, Mettupalayam, Tamil Nadu.

3 -Scientist-C, P4 Unit, Muga Eri Silkworm Seed Organization, Central Silk Board, Tura, Meghalaya, India.

*Corresponding Author Email ID: ythangamalar4@gmail.com

Introduction

The mulberry plants which are allowed to grow tall with a crown height of 5-6 feet from the ground level having stem girth of 4-6 inches or more inches are called tree mulberry. They are specially raised with the help of well grown saplings of 8-10 months old with any of these varieties recommended for rainfed area like s-13(red loamy soil) or s-34 (black cotton soil) which are tolerate to drought or soil moisture stress. Usually the plantation is raised as block plantation with a spacing of 6 ft×6ft (or)8ft×8ft as plant to plant and row to row distance. The plants are usually pruned once in a year during monsoon (July-Aug) at a height of 5-6 ft from the ground level and allowed to grow with maximum of 8-10 shoots at crown. The leaf is harvested 3-4 times in a year by leaf picking method under rainfed or semi-arid conditions depending upon the monsoon.

Concepts of tree mulberry plantation

Combining trees and field crops in arable land is called as “Agro-forestry’’. The objective of agro-forestry is to improve the productivity and sustainability of land management system through introduction of woody perennials in herbaceous crop husbandry. Selection of tree species to be used in agro forestry must be based on cultural and economic as well as environmental and biological factors. Thus growing mulberry as tree in highly eroded flat to gentle sloppy land unfit for growing arable crops, arable soil fertility problems, degraded sloppy land can serve as one of the best means of agro-forestry.

Who can grow tree mulberry?

Mulberry is a perennial plant with reasonably drought tolerance capacity. It can be cultivated as a trained tree mulberry by maintaining specific spacing between trees and crown height. This type of mulberry plantation is highly suitable for farmers of semi-arid / rainfed areas in plain land, hilly regions or in denuded land unsuitable for agriculture this form of cultivation is already been practised in temperate and hilly regions. Of late, the concept of tree cultivation has also spread the plains as a sustainable crop under severe water stress condition in waste and denuded lands. With the recommended packages, it is how possible to get about 6-8 MT of mulberry leaf yield/hec/yr through 3-4 harvests.it is also possible to take up appropriate intercrops in the tree mulberry plantation to reap higher economic benefits. Considering the above, Mulberry can be cultivated under rainfed conditions with different systems of cultivation. These include,

a) Bush system of mulberry cultivation; under protective irrigation.

b) low-height tree type mulberry cultivation, suitable in hilly regions.

c) tree mulberry cultivation: best suited to overcome acute water stress conditions.

Packages of practices for mulberry tree plantation;

Development of mulberry tree saplings

The mulberry saplings are developed in the nursery. A flat nearer to water source is preferred as nursery site. Well drained land with loamy soil is ideal for nursery. The land must be ploughed or dug 30-40 cm deep and allowed for weathering in sun for 2-3 weeks. Land is again ploughed two or three times to bring the soil to fine tilth. Rootstocks, pebbles and weeds are removed at the time of ploughing and the land is levelled. The land is divided into a no.of.small beds to prepare the nursery. The size of each bed is decided keeping working convenience into mind. A bed size of 3.0m(l)×1.2(b) accommodates 100 cuttings (row to row 30cm,cutting to cutting in a row 10 cm distance) to raise 8-10 months old saplings. Each bed on all sides is separated by a bund of 25-30 cm width 15-20 cm depth. Each bed should be manured and mixed thoroughly with 5 pans of FYM/sericulture compost/vermicomposting. In the case of clayey or black cotton soil, additionally 5 pans sand/bed should be mixed with soil uniformly. In the case of red loamy or sandy loam soils, there is a possibility of termite infestation as a preventive measure, 0.1% chloropyriphos (5ml/lit) can be sprayed to drench the soil of nursery beds (2-3 litre /be). Regular care and irrigation should be provided for good growth.

Transplantation of saplings from the nursery

For tree plantation, the saplings are transplanted from the mulberry, after 8-10 months of maturation. The matured saplings are removed from the mulberry. By deep digging and without damaging the roots. It is advisable to irrigate the nursery beds thoroughly at least 2-3 days before uprooting to facilitate easy and complete removal of saplings with roots intact. The uprooted saplings are immediately planted in the main field after removal of leaf, top clipping and dipping the roots of the plants in 0.2% solution of Diethene M-45 to avoid fungal root diseases.

Plantation of saplings in the main field

At flat/sloppy land with red loamy/black cotton soil or denuded land not suitable for other agricultural crops can be selected for raising tree mulberry as block plantation. Plantation can be taken only during raining season preferably in July- September or depending upon the onset of monsoon. The land should be thoroughly ploughed by tractor/bullock plough depending upon the soil condition after receiving one (or) two pre monsoon shower and weeds should be removed.

Establishment care

Once the land is made ready, farm yard manure/sericulture compost can be applied 10 MT @ ha and mixed with well the soil. It is highly necessary to follow soil moisture. Conservation practise by raising wide bunds all along the four boundaries of the plantation to avoid runoff and allow rainwater percolation in the planted area during monsoon. Before plantation, pits of the size of 35cm (l)×35 cm (b)×35 cm (d) are dug at 8 ft apart from the each considering plant to plant and row to row distance as 8 ft×8ft. each pit is then planted with one transplanted matured sapling exactly in the centre of pit. To determine centre of the pits and to keep the rows straight to avoid zigzag plantation, two ropes are used length and breath wise and the intersecting point of the two ropes is considered as the centre of each pit. The pits are filled with soil and pressed properly for better anchorage with the ground. Once the plantation is over, all the planted saplings are pruned properly uniformly at 5ft height (crown height) from the ground level within 2-3 weeks and allowed to grow for 8-10 months as establishment period or even a year without harvesting leaf/disturbing the plants. However weeding should be done as and when required during the establishment period to facilitate to better growth. After 4-5 months of urea/ammonium sulphate is applied near each plant by making basin and irrigation is followed. If required gap filling can be made with properly grown saplings. Plants should be given lifesaving irrigation as and when required in non-rainy period for better establishment. further, the whole planted area can be divided into small blocks of 15-20 plants in each having wide bunds all among the four sides to allow in-situ soil moisture conservation during rainy season. During the establishment period. The plants may attain a height of 10-15 ft from the ground level within 3 -4 branches if properly maintained.

Pruning and packages to be followed by second year;

Once the plantation is establishment properly, the plants are pruned uniformly at the same crown height (5ft) where the plants were pruned earlier during the time if plantation. This should invariably be followed only during rainy season (July-Sep) to facilitate the vigorous growth of shoots from the second year onwards. Farm yard manure @ 10 MT /ha/yr is applied within a week of pruning and the weeding is followed with the help of tractor / power tiller/country plough to plough to mix the manure with soil and to save the manual labour days. Immediately after this basins around, the plants are cleaned to apply fertilizers and allowing rain water percolation near the plants. Depending upon rainfall, chemical fertilizers NPK is applied @ 150:60:60 kg/ha/yr. In two equal splits in the form of ammonium sulphate for alkaline soils, urea for acidic soils in early and later part of rainy season.

Green manuring with sunhemp or daincha for the improvement of soil fertility and water holding capacity or intercropping with short duration crops (Groundnut, Cowpea, Horsegram, Ragi etc). For augmenting income can also be done from the second year onwards. If the plantation is inoculated with VA-mycorhiza followed by manuring, reduces the doses of FYM & NPK fertilizer can be applied @ 10 MT and 50:25:25 kg/ha/yr respectively. aleaf can be harvested by individual leaf picking and soil moisture condition. Thus is possible to harvest 3-4 crops annually ranging from 7-8 MT/ha/yr.

Necessities of tree mulberry

Poor rainfall,limited water resources for mulberry cultivation,expensive and expensive and non-availability of manpower.

Inconvenient paired row spacing for mechanization causing huge weeds leading to multiple pathogen attack on mulberry.

Prolonged dry spell leading to wilting of leaf, inadequate & poor quality leaf production.

Due to the above skipping of minimizing the rearing during the drought spell (Oct-Dec, Jan-Feb)

How tree mulberry beneficial:

- Tree mulberry withstands drought conditions due to its firm tree from and deep root systems.
- Perform well in all seasons even under limited water availability and low rainfall circumstances.
- Minimises manpower drudgery on irrigation and cultivation due to mechanization.
- Economizes plant wise fertilizers & manure application avoiding wastages.
- Minimum pest & disease occurrence due to aeration and tree habitat.
- The last but not least convenient for mechanized tillage by using power tiller, mini-tractor, tractor.
- Uniform enhanced quality mulberry leaf ideal for silkworm rearing leading to quality cocoon with enhanced market rate.

Suitable season to undertake mulberry

With the onset of monsoon (June-July) land preparation and plantation can be planned. 5-6 months old v1 or G4 saplings planted in 1 ft to 1.5 ft deep pits supplementing with > 1 kg FYM.Suitable spacing like (4’×6’) (5×6’) for small and medium farmers (4’×8’) (5’×8’)and (4’×10’) (5’×10’) for large farmers accommodating 850-1800 plants/acre for mechanization and economically viable farming. while plantation sapling can be cut of upto 1-1.5 ft height from the ground for convenient operation even upto 10-15 yrs.Monsoon showers helps plant to establish in 5-6 months.(from the bottom) to give crown form. Maintenance appropriate 1st harvest possible after 6months of plantation and used for rearing 50 dfls/acre as first rearing.

1st harvest-50 dfls/acre

2nd harvest-100 dfls/acre

3rd harvest – 150 dfls/acre

2nd year- 5 crop schedule

brushing 200-250 dfls/acre/crop.

Economical gain of tree farming and silkworm rearing

Tree mulberry is proved to be beneficial in case of plantation as well as silkworm rearing.In plantation limited planting material, easy to plantation, maintenance and establishment.Economic in maintenance with drip irrigation, reduced level of manures and fertilizers without wastage. Easy maintenance compared to paired row spacing due to mechanization with less drudgery of manpower.

Advantages in tree mulberry

- Enhanced uniform quality, disease & pest free leaf production leading to successful bivoltine sericulture.
- No rearing crop losses with enhanced uniform quality of bivoltine cocoon production with increased market rate.
- Enhanced cost benefit ratio in case of leaf production1:3 8’×3’) increased C:B ratio of cocoon production 1:3.8 in 8’×3’.
- Central & state sericulture Govt decided to support tree mulberry farming among all farmers.

Conclusion

Tree mulberry farming planted in 8’×3’ spacing with 4547 plants/hectares. Tree mulberry farming has shown its resistance and tolerance level to the extreme drought prone situation because of its deep root system with strong and well established firm aerial stem promoting silkworm rearing in all seasons. Paired row spacing (13,888 plants) indicating difficult to maintain under scarce water availability and also showing wilting symptoms in summer crops. The tree farm of mulberry is an imperative to not only enhanced uniform and assured leaf production but also to combat with acute drought stricken climatic conditions.

Reference

Anonymous, 2017. annula report, Central Silk Board, Karnataka .1-100.

Dandain, S.B. Jayaswal.J.and Giridhar.K. 2003. Hand book of sericulture technologies, Central Silk Board, 259.

Volume: 04 Issue No: 12

PHYTOREMEDIATION: A SUSTAINABLE ENVIRONMENTAL APPROACH FOR REVEGETATION OF SALT-AFFECTED SOILS

Article ID: AG-V04-I12-23

***T. Sherene Jenita Rajammal, M. Baskar, M.Vijayakumar and P.Vaishnavi**
Department of Soil Science and Agricultural Chemistry,
Tamil Nadu Agricultural University,
Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli,
Tamil Nadu, India
*Corresponding Author Email ID: shereneraj@yahoo.co.in

Introduction

Salt-affected soils pose a significant environmental challenge, particularly in arid and semi-arid regions around the world. Soil salinity and sodicity have become increasingly detrimental environmental factors that significantly affect plant growth. Phytoremediation offers an environmentally friendly and cost-effective solution to restore salt-affected soils. Although various physical, chemical, and biological methods have been developed to address this issue, phytoremediation stands out as an innovative strategy for soil remediation. This approach uses halophytes, or salt-tolerant plants, to extract salts from the soil through processes such as phytoaccumulation, phyto-stabilization, phyto-desalinization, and phyto-transformation. Halophytes like *Salicornia europaea*, *Sesuviumportulacastrum*, *Portulaca oleracea*, and *Suaeda maritima* are well-suited to saline environments and can reduce soil salt concentrations.

Characteristics of salt-affected soils

According to the 1954 guidelines from the United States Department of Agriculture (USDA) Soil Salinity Laboratory (USSL), salt-affected soils are generally categorized into three types: saline soil, sodic soil, and saline-sodic soils. These classifications are based on the types and concentrations of salts present in the soil, as outlined below.

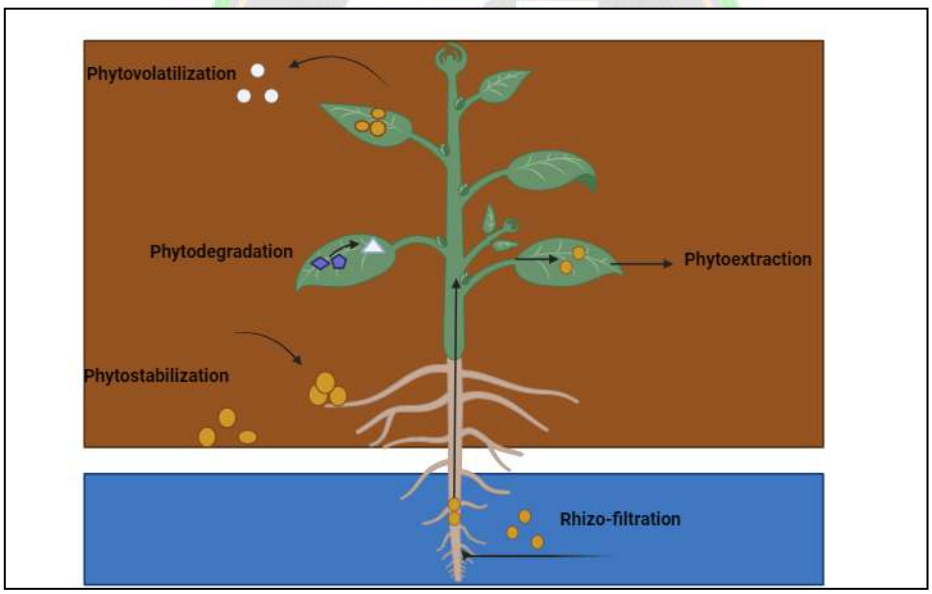
Classification of salt-affected soils(USSL, 1954)

Soil class	ECe (dSm^{-1})	ESP	pH
Saline	>4	<15	8.0 - 8.5
Saline –sodic	>4	>15	>8.5
Sodic	<4	>15	>8.5

Phytoremediation for salt-affected soils

Phytoremediation of salt-affected soils involves cultivating plant species that can either accumulate or tolerate high levels of salt to reduce soil salinity or sodicity. This method, which uses salt-tolerant vegetation like trees, shrubs, and grasses, presents a cost-effective and environmentally friendly solution for restoring degraded soils impacted by salinity.

Example: Common glasswort, Dwarf saltwort, Dwarf glasswort, Toothbrush tree, Purslane, Sea Purslane



Different mechanisms of phytoremediation (phytovolatilization, phytodegradation, phytoextraction, Phyto stabilization and rhizo-filtration) Source: Bio render

Different mechanisms involved in phytoremediation

Phytoaccumulation

Plants take up salts from the soil and concentrate high levels of Na^+ and Cl^- ions in their shoots. For example, *Cynodondactylon* accumulates these ions in specialized salt glands, while

Thinopyrumpergranulata stores salt within its cells. This mechanism effectively reduces the concentration of these ions in the soil.

Phytoextraction

Plants effectively reduce excess salts in the soil through root absorption, storing them in their biomass in a process known as phytoextraction. This not only decreases the levels of exchangeable sodium and soluble salts but also boosts the organic carbon and nutrient content of the soil. Over time, this leads to improvements in the soil's physical properties (such as bulk density, porosity, infiltration, and water-holding capacity), chemical properties (including nutrient availability), and biological properties (such as microbial populations). Collectively, these changes enhance the overall productivity of the soil.

Phyto-stabilization

Phyto-stabilization, or phyto-immobilization, is a technique used to limit the movement and bioavailability of salts in environments affected by salinity. This process consists of two key stages: (a) immobilizing salts in the root zone and (b) retaining salt ions primarily in the roots rather than allowing them to move into the shoots. Storing most of the absorbed salts in the roots is an effective approach for managing soil salinity. For example, Populus alba can retain 90% of Na^+ in its roots.

Phyto-transformation

Phyto-transformation involves three phases: a) the initial absorption of high concentrations of salt ions from the soil, b) their subsequent translocation into plant tissues, and c) their conversion into less toxic or non-toxic compounds through various metabolic processe.

Phyto-desalination

Phyto-desalination represents a cutting-edge and developing approach to phytoremediation. This technique utilizes halophytes to remove salts from salt-affected soils, thereby creating favorable conditions for the growth of more conventional plants. Halophytes are naturally adapted to manage salt ions more effectively than glycophytes. For example, *Sesuviumportulacastrum* and *Suaeda maritima* have been shown to remove 474 kg and 504 kg of NaCl, respectively, from one hectare of saline soil within four months.

Phytovolatilization

Phytovolatilization is a phytoremediation process where contaminants are absorbed by plants from the soil, transformed into volatile compounds, and then emitted into the atmosphere.

While this mechanism reduces the concentration of pollutants in the soil, it does not fully eliminate them but rather transfers them from the terrestrial environment to the atmospheric compartment.

Phytodegradation

Phytodegradation is a mechanism where plants metabolize organic pollutants through enzymatic activity, involving enzymes like oxygenases and dehalogenases. This process is heavily dependent on the interaction with soil microorganisms and applies exclusively to organic contaminants.

Accumulation of salt in halophytic plants

Halophytes are plants that can thrive in high-salinity environments, often referred to as salt-tolerant plants. The halophyte plants are classified based on their habitats such as non-halophyte, obligate halophytes and facultative halophyte (Fig.2). The halophyte salt gland structures, consisting of epidermal cell complexes, facilitate the extraction and transport of salt from mesophyll cells through plasmodesmata. This salt is then secreted onto the leaf surface, where it crystallizes (Hasanuzzaman et al. 2014; Fig. 8). Certain halophytes possess multicellular salt glands and salt hairs, which are prevalent in species such as *Cressa* (Convolvulaceae), *Frankenia* (Frankeniaceae), *Spartina*, *Chloris*, and *Aeluropus* (Poaceae), *Atriplex* (Chenopodiaceae), *Statice*, *Limonium,Plumbago*, and *Armeria* (Plumbaginaceae), *Glaux* (Primulaceae), *Tamarix* and *Reamuria* (Tamaricaceae), and some mangrove species like *Avicennia*, *Aegialitis*, *Aegiceras*, and *Acanthus*.

Halophyte species and their salt accumulation

S. No.	Halophytes species	Salts
1.	*Atriplex triangularis*	Mg^{2+}, Na^{+}
2.	*Suaeda glauca*	Mg^{2+}, Na^{+}
3.	*Suaeda salsa*	Na^{+}, Cl^{-}
4.	*Phragmites australi*	Cl^{-}
5.	*Tecticorniapergranulata*	Na^{+}
6.	*Sclerolaenalongicuspis*	Na^{+}

7.	*Frankenia serpyllifolia*	Na^+
8.	*Sesbania sesban*	Na^+, Cl^-
9.	*Acacia dealbata*	Na^+, Cl^-
10.	*Sesbania rostrata*	Na^+, Cl^-
11.	*Kalidium folium*	Na^+, Cl^-
12.	*Phaseolus filiformis*	Na+
13	*Phaseolus acutifolius*	Na+
14.	*Atriplex hortensis*	Na+
15.	*Senegalia Senegal*	Na+, Cl-
16.	*Prospisjuliflora*	Na+, Cl-
17.	*Vacelliaseyal*	Na+, Cl-
18.	*Tetragoniatetragonioides*	Na+, Cl-
19.	*Sesuviumportulacastrum*	Na+
20.	*Arthrocnemum indicum*	Na+
21.	*Suaeda fruticose*	Na+
22.	*Suaedaportulacastrum*	Na+
23.	*Atriplex halimus*	Na+

Conclusion

Phytoremediation emerges as a promising solution, utilizing salt-tolerant plant species to rehabilitate salt affected soils sustainably and cost-effectively. These plants not only absorb excess salts but also improve soil structure and nutrient content, fostering enhanced agricultural productivity. Also, salt-tolerant plants could be able to accumulate the translocated salts from root to shoot /leaves and not on economical produce. Halophytes exhibit remarkable adaptations to saline environments, employing mechanisms like ion exclusion and accumulation to thrive under stress.The increasing global salinity problem, which has detrimental effects on all forms of life, including humans, has spurred the need for less harmful technologies to mitigate soil salinity. The use of halophytes has been shown to effectively remediate soil salts. However, existing reclamation methods for salt-affected soils require substantial quantities of high-quality irrigation water, along with gypsum amendments that are both scarce and have poor dissolution rates. This is the added advantage of phytoremediation technology over the existing gypsum reclamation technology.

Volume: 04 Issue No: 12

MEDICAL TEXTILES

Article ID: AG-VO4-I12-24

***Mrs. Radhika Damuluri[*1], Dr. Neela Rani [2] and Dr. Shirin Hima Bindu[3]**

[*1] Scientist, AICRP on WIA, PJTAU, Rajendranagar, Hyderabad, [*2]Principal Scientist, AICRP on WIA, PJTAU, Rajendranagar, Hyderabad, [*3] Scientist, AICRP on WIA, PJTAU, Rajendranagar, Hyderabad, India

*Corresponding Author Email ID: radhikackrishna@gmail.com

Introduction

Textile materials used in the medical and health care and hygiene sectors are important and growing part of technical textile industry. All textiles used in surgical and post-surgical activities in and around the patient and health care professionals are termed as medical textiles. The key meditech product is surgical dressings, which accounts for 50% of total technical textile consumption in meditech segment. Surgical sutures account for 21% of the total consumption, followed by contact lenses 12% and artificial implants 8% respectively in the total consumption. The non-woven, disposables accounts for 2% of technical textiles usage among meditiech and sanitary napkins account for 1.65%. The artificial implants are imported, contributing to 15% of domestic production in total usage. The availability of nonwoven fabrics is limited in India. Hence nonwoven products such as baby and adult diapers are primarily imported. By 2020 the meditech industry is expected to grow at the rate of 8-9% annually.

Classification of medical textiles:

From the point of view of practical application, medical textiles are classified as

1. Non-implantable materials: bandages, wound care, plasters and gauze
2. Health-care and hygiene products: surgical clothing, covers and bedding
3. Implantable materials: Sutures, Soft Tissue Implants and Hard Tissue Implants
4. Extra-corporeal materials: Artificial Kidney, Artificial Liver and Mechanical Liver

Non-implantable materials

Bandage

A bandage is a piece of material used either to support a medical device such as dressing or splint or on its own to provide support to the body risk of infection, . It protects and supports an injured part of the body. They are available in a wide range of types, from general cloth strips to specialized shaped bandages designed for a specific limb or part of the body.

i. **Gauze bandage:** it is made of thin and loosely woven plain fabric with a very open weave which is air permeable and absorbent. Gauze is a highly absorbent material, classically made with cotton, often saturated in an antimicrobial solution to reduce the risk of infection. The gauze generally treated with clotting agents, to stop bleeding on wounds. It is used primarily on wounds of fingers, hands, feet, toes, eyes, ears and head.

Gauze bandage

ii. **Support bandage:** it is a form of bandage that assists in healing of injured muscles, bones, helps to reduce bleeding from a wound or to provide support to prevent injuries from occurring. First aid kit consists of a variety of supportive bandages like elastic bandage, adhesive bandages, compression bandages etc., which are typically made of elastic cloth. The type of support bandage which should be used varies, based on the intended purpose of the dressing. A bandage should not replace medical treatment but, rather offer support to the effected area until the injured person can be seen by a doctor.

Various types and applications of support bandages

Different types of support bandages:

- Compression bandages: this bandage is made of a stretchable fabric that is wrapped multiple times around a body part and can be secured with metal clips. It can be used to restrict the blood flow to an injured area. It can also be used on other areas of body to secure a splint.
- Cloth compression bandage: it is often used to offer support against injuries to various body parts while participating in sports or exercise. These supportive bandages can help to prevent damage and injury to the area in which it is applied. Many athletes use bandages to cover are as most likely to be harmed, such as joints.
- Pressure bandage: it is a form of support bandage that can provide assistance in decreasing the amount of blood loss by an injury. In extreme cases, a pressure bandage is applied over gauze in order to apply extra pressure, to stop blood flow from a wound. Small adhesive bandages can also be considered pressure bandages, so they help stop the bleeding of minor cuts and abrasions. They also act as a sterile bandage to keep the area free of germs and infection.

iii. **Stretch bandage:** they are made of the fabric which is slightly stretchy so that it can wrap easily around difficult to bandage areas, such as elbow or knee joints. It can be classified in to two types in relation to amount of stretch i.e short stretch bandage and long stretch bandage.

a. **Short stretch bandage**: it puts pressure on the skin and muscles to improve absorption of fluids. As the person moves the injured limb, an arm or leg or hand, the bandage provides a massaging action on the muscles that could speed up the localizing process. It is generally comfortable for long term wear and do not have to be removed overnight.

Uses of short stretch bandage:

❖ A short stretch bandage is used to reduce swelling in a limb.

❖ They are often used as one layer in a system of 3-4 layers of bandaging for compression treatment of patients with chronic swelling issues.

❖ Short stretch bondages are also used in the treatment of lymphedema, which is swelling caused by a blockage in the lymphatic system.

Different types of materials used with short stretch bondages

Tube fabric

Padding

Wrapping of short stretch bandage

b. **Long stretch bandages:** they have the ability to stretch quite far, more than twice their original size. However, they also have high resting pressure and must be removed at night or when the patient is at resting position. Long stretch bandages don not provide the massaging effect that short stretch bandages provide.

Uses of long stretch bandages:

- ❖ Long stretch bandages are used for sport injuries.
- ❖ They are used to wrap sprains or other soft-tissue injuries.

c. **Crepe bandage**: cotton crepe fabric is made up of plain weave, in which warp threads are made with two-fold cotton threads, crepe twisted to contain not less than 17 turns per cm, and the weft threads are of cotton, viscose or combination of cotton and viscose yarn. The warp threads are arranged in such a way that two threads have S-twist, and two threads Z-twist repeated.

Applications of crepe bandage:

- ❖ General surgical, orthopaedic and sports injuries
- ❖ Extremely convenient as a pressure dressing and for skin grafts
- ❖ Used for sprains, aches, dislocation, painful joints and vein cramps
- ❖ Very useful for muscular support

Unconventional bandages:

They are designed and engineered to meet specific requirement. Recent advances in bandages are antimicrobial bandages, drug releasing bandages, bandages and so on. specially coated or treated bandages, smart bandages and so on.

- War bandages: unstoppable bleeding is one of the leading causes of death in war field. For this reason, war bandages are specially developed, which contain chitosan molecules, which have a + ve charge. The outer membrane of RBC have -ve charge, which is attracted to the chitosan. As soon as the chitosan comes in contact, the RBC fuse and form clot against chitosan, which forms a very tight and adherent clot.
- Drug releasing bandages: adhesive bandages specifically designed to provide medication through skin, rather than protecting a wound. It is also called as transdermal bandage or skin patch. Transdermal drug release is non-invasive delivery of medications from the surface of the skin through its layers, to the circulatory system. Drug releasing bandage is a medical adhesive pad that releases the active ingredient at a constant rate over a period of several hours to days after application to the skin. It uses special membrane to control the rate at which the drug contained within the patch can pass through the skin and in to blood stream. Medicated patches – eg: nicotine patch, oestrogen patch, insulin patch etc.; non-medicated patches – eg: thermal and cold patches, weight loss patches, nutrient patches, skin care patches, aroma patches etc.
- Plaster-of-Paris bandage: they consist of leno weave bleached cotton gauze impregnated with calcium sulphate to which adhesive has been added. The mass of Plaster-of-Paris bandage should not be more than 340gm/m2.
- First-aid dressings: it consists of an absorbent pad covered with an ant-static material fixed to a self-adhesive plaster. The pad and the adhesive margin are covered with a suitable protector. The pads are medicated with any permissible antiseptic. The dressing may be sterilized or medicated.
- Paraffin gauze dressing: it is fabricated using open weave leno gauze with interlocking threads. The paraffin acts as a soothing agent and it contains antibacterial/ antiseptic that helps in healing. Coated with soft paraffin jelly, mainly used on the uncovered areas. These are mainly used for treatment of wounds such as burns, scalds, skin grafts.
- Surgical sutures: they are used for stitching together skin deformations, open wounds, organs and blood vessels. They are categorized as absorbable suture – get dissolved in the body and does not require removal; non-absorbable suture – sterilized suture which needs to be removed after a specific time. The raw material for sutures range from bovine intestine

tissues to Poly Glycolic Acid (PGA), collagen, mono filament polymer or polypropylene and multi-filament nylon/ polypropylene/ polyamide.

Health and hygiene products

Baby diapers: diaper is used for wrapping the newly born or young children, who have not developed the fixed routine toilet training. Diapers retain the liquid for about two hours or so, to absorb the urine during the miction. Hence baby diapers require properties should be soft, highly absorbent (should absorb 30-60gm of urine without feeling wet), non-irritating, provide protection against leakage, should not re-wet, comfortable, proper fit and bio-degradable.

Composition of diaper:

core (70%) – consists of pulp and super absorbent material.

Polypropylene (10%) – A top PP sheet to protect the baby's skin from re-wetness.

Polyethylene (13%) – back sheet of diaper consists of mostly polyethylene and provides leakage protections for the baby clothes.

Incontinence diaper / adult diaper: Incontinence diaper are for people with loss of bladder control typically for elderly people. They are disposable, single use products specifically designed to absorb and retain fluids. They are made of absorbent material of cellulose with poly-beads to convert fluid in to gel. The non-woven layer is placed on top to keep the wearer dry.

Sanitary napkin: use of protection during menstruation in the form of a pad or napkin is mandatory. The kind of protection used determines the hygiene status of woman. A sanitary napkin comprises of three layers, top layer, absorbent layer and barrier sheet. The extent to which the absorbent layer able to absorb the fluid determines the efficiency of the napkin.

Surgical gown: surgical gown is a medical device intended to be worn by operating room personnel during surgical procedures to protect both the surgery patients and operating room personnel from transmitting microbes, body fluids and particulate materials. Two types of surgical gowns are commonly used viz. single use, non-woven, disposable surgical gowns and reusable woven surgical gowns.

Woven reusable surgical gowns: they are generally made with cotton/cotton or cotton/ polyester. Polyester provides comfort as well as barrier functionality. Plain weave or twill weave are usually used. Though the woven fabrics are most suitable, due to comfort in wearing, the pore size is large enough to allow fluid or viruses to pass through, thus provide no barrier function. Densely woven microfilament fabrics are treated with liquid repellent finish. Triple layer fabrics are used for surgical gown to meet various desired qualities, outer layer – to resist abrasion and puncture, middle layer – provides barrier resistance to fluid penetration, soft bottom layer – adds comfort, another layer for protection. A tri-laminate is also produced through combining a micro-porous membrane, bonded between layer of end-less fibre polyester. Mechanical stretched PTFE membranes are also used on surgical gowns to resist fluid and virus contact.

Non-woven single use surgical gowns: during the recent times three types of nonwoven fabrics viz. spun-laced, melt-blown and a 3-layer composite (spun-bounded, melt-blown, spun-bonded, SMS) has been frequently used for the production of single use surgical gowns, as they provide better barrier properties than spun-laced nonwovens.

Face mask: A surgical face mask is an important medical device used to protect both patients and health care professionals from the transfer of microbes, body fluids and particulate material, bacteria shed from liquid droplets from the wearer's nose and mouth. Due to current COVID pandemic scenario it has become mandatory for people of all ages to wear face mask and maintain social distancing to prevent spread of the pathogen.

Alcohol swabs: they are used to clean the injured site or before injecting medicine. They also used to wipe-off blood from wounds, injection sites and single use only. Alcohol swabs should not be shared.

Implantable medical devices

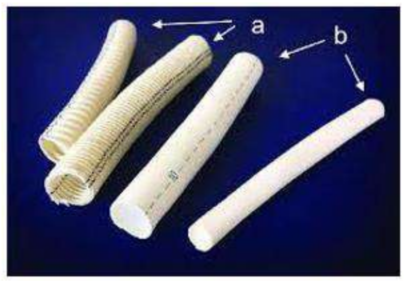
Artificial heart valves:

They are implanted in the heart of the patient who needs treatment for valve related diseases. The natural heart valve requires replacement when two or more valves stop functioning properly. The mechanical heart valve consists of Ultra-High Molecular Weight Polyethylene (UHMW-PE) disc, low density polyethylene plastic with knitted polyester sewing ring and a metallic housing. The sewing ring is fabricated from extensively tested 100% polyester material. The heart valve market in India is approximately 74 crores.

Mechanical and Tissue Mitral Valves

Artificial vascular grafts:

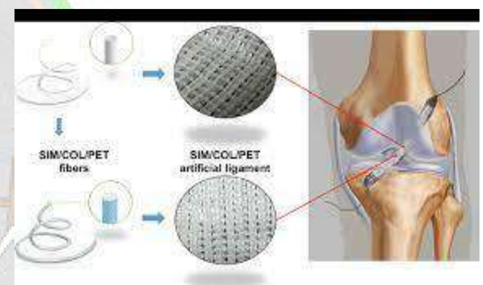
Vascular diseases are characterized by variations to the geometry and structure of the blood vessels. Variations in the mechanical characteristics of the vessels result in multiple complications like thrombosis, aneurysm and arteriosclerosis. The grafts need to have special characteristics for effective functionality such as non-thrombogenic surface, durability, bio-compatibility, bacteria resistance, long term tensile strength and elasticity. Woven or knitted fabrics are used for prosthetics. Knitted fabric is easy to suture and most suitable for aortic replacement but not for larger diameter vessels. The knitted fabric is porous, needs to be clotted with patients' blood before usage. Woven fabric has strong construction but difficult to suture. Most textile grafts used for large and medium artery replacement are made of PET or PTFE.



Artificial vascular grafts

Artificial tendon :

Artificial tendons or meshes are used in hernia operation and abdominal wall replacement, where mechanical strength and fixation are very important. The long-term function of the mesh is optimized by adjusting the porosity and texture of the mesh. The mesh could be either woven or knitted based on requirement of strength. Polypropylene and polyester mesh is used in hernia operation due to its resistance to infections.



Artificial tendon

Artificial joint:

The artificial joints are used for patients suffering from arthritis and accidental damage of joints. The textile component used is Ultra-High Molecular Weight High Density Polyethylene (UHMWHDPE). The market for joints in India is 4.5 crores approximately.

Artificial joint

Artificial ligament:

This is a medical device used for joining ends of two bones. They are made from man-made fibres like polyester.

Artificial ligament

Ligament is a multi-layered or tubular woven structure having intra-articulate region, at least one bend region and end regions. Each region is woven, so as to possess the required flexibility and strength. Polyethylene Tetra phthalate (PET) is primarily for manufacturing of ligaments. The artificial ligament must be bio-compatible with contact blood and tissue and should have good bonding strength. The artificial ligament industry is small in India and primarily imported.

Artificial skin:

Artificial skin

Skin grafting is the procedure used to replace dead skin with live skin. After removing the burnt or damaged skin, surgeons blanket the wound with a covering i.e artificial skin, before applying skin graft on top of this bio-material to encourage the growth of new skin to close the wound. Artificial skin consists of two layers. The bottom layer, which regenerates the lower layer of real skin is composed of a matrix of interwoven bovine collagen and a sticky carbohydrate molecule, glycosaminoglycan, which mimics the fibrous pattern of the bottom layer of skin. This matrix then sticks to a temporary upper layer: a medical grade flexible silicon sheet that mimics the top layer of skin. The artificial skin market in India ia negligible due to high cost.

Artificial heart:

Artifical heart

The artificial heart is intended for use in patients whose hearts have been irreparably damaged and existing surgical interventions and drug therapy and inadequate. Heart transplantation is limited by availability of donor organs. Hence there is immense potential for artificial hearts. However, the device is very expensive.

Artificial kidney/ Dialyzers:

Kidney serves the function of filtering blood. The mechanical replacement for kidney is dialysis machine. It is used outside the body and purifies blood using the hemodialyzer, which is made of polysulphone and polyacetate. The primary function of the artificial kidney is to filter blood using filtration medium used in hollow viscose or polyester fibre.

References

Ketan Kumar Vadodaria., Thiruppathi. S., (2016) Winter School on "Smart Functional Textile and Apparel to Combat Extremities: A Futuristic Approach" (1st to 21st December).

https://science.howstuffworks.com/innovation/everyday-innovations/artificial-heart.htm

https://pubs.rsc.org/en/content/articlelanding/2020/bm/c9bm01445d/unauth

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

SMART FARMING: HARNESSING TECHNOLOGY FOR OPTIMAL CROP MANAGEMENT

Article ID: AG-VO4-I12-25

***Dr. Prakash Gamar, **Mr. Rahul Damor, ***Dr. V. N. Patel, ****Dr. Y. H. Rathwa**

*(College of Veterinary Science & Animal Husbandry, KU, Himmatnagar)

**(College of Veterinary Science & Animal Husbandry, KU, Himmatnagar)

***College of Agriculture, AAU, Jabugam

****Director of Extension Education, AAU, Anand

*Corresponding Author Email ID: prakash.gamar@gmail.com

Introduction

Precision agriculture, also known as site-specific crop management (SSCM), is an innovative farming approach that uses modern technologies to manage agricultural production in a more targeted and efficient manner. This method involves the use of data, sensors, GPS (Global Positioning Systems, drones, and advanced analytics to monitor and manage field variability in crops and soil. By collecting precise data on variables such as soil health, crop growth, weather patterns, and irrigation needs, precision agriculture helps farmers make informed decisions that improve the productivity, efficiency, and sustainability of farming operations.

The key goal of precision agriculture is to apply the right amount of inputs (water, fertilizers, pesticides, etc.) at the right time and in the right place, optimizing crop yield while reducing costs, resource waste, and environmental impact. This approach can lead to higher yields, improved environmental outcomes, and lower operational costs, contributing to more sustainable farming practices.

Definition

Precision agriculture refers to the use of advanced technologies and data-driven techniques to monitor, analyse, and manage agricultural operations at a high level of specificity. It involves the use of tools like GPS, remote sensing, drones, sensors, and big data analytics to assess field variability and apply agricultural inputs in a controlled, site-specific manner. This methodology aims to increase crop productivity, reduce input costs, minimize environmental impact, and enhance overall farm management through precise, data-driven decision-making.

Key Technologies Used in Precision Agriculture

1. **Drones:**

Drones are increasingly used in Indian agriculture for various purposes. They provide real-time aerial imagery and allow farmers to conduct field surveys to monitor crop health and detect pests or diseases. Drones can be used for:

- **Aerial Mapping:** Providing accurate, detailed maps of the fields to identify variations in soil and crops.
- **Pesticide and Fertilizer Spraying:** Drones can spray pesticides, fungicides, and fertilizers precisely over specific areas, which reduces chemical usage, labour costs, and environmental impact.

2. **Sensors:** Sensors have revolutionized the way farmers manage soil and crop health. These include:

- **Soil Moisture Sensors:**

  These sensors measure the soil's moisture content, helping farmers to optimize irrigation schedules and reduce water wastage.

- **Climate Sensors:**

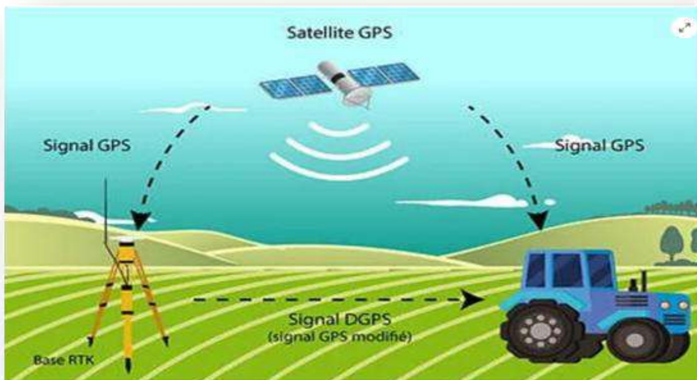
  These monitor environmental factors like temperature, humidity, and rainfall, providing critical data for planning the right irrigation and fertilizer application.

➢ **Nutrient Sensors:**

Soil health can be monitored through sensors to determine nutrient levels, ensuring that fertilizers are applied in the correct quantity and only when necessary.

3. **GPS and GIS:**

- ✓ **Global Positioning System (GPS):** GPS technology enables farmers to operate machinery with precision, minimizing overlaps and missed areas, which is crucial in planting, fertilizing, and spraying operations.



- ✓ **Geographic Information System (GIS):** GIS allows farmers to map out fields, collect data on crop performance, and plan interventions based on spatial variations. It provides insights into factors such as soil health, crop rotation needs, and water distribution.

4. **Data Analytics and Artificial Intelligence (AI):**

Data analytics and AI are helping farmers process large volumes of data collected from sensors, satellites, drones, and other sources. Some applications of AI and data analytics in Indian agriculture include:

- ✓ **Yield Prediction:** AI models can predict crop yields based on factors such as weather patterns, soil conditions, and past performance, helping farmers plan better.
- ✓ **Pest and Disease Detection:** Image recognition technology and machine learning algorithms can identify signs of pests or diseases on crops. Early detection can significantly reduce crop loss by enabling timely interventions.

- ✓ **Weather Forecasting:** AI and data analytics help provide more accurate weather forecasts, which are essential for determining planting times, irrigation schedules, and harvest planning.

5. **Irrigation Management Systems:**
   - ✓ **Drip Irrigation:** This method delivers water directly to the roots of plants through a network of pipes, reducing water wastage. Precision irrigation systems ensure that crops receive the optimal amount of water.
   - ✓ **Automated Sprinklers:** These systems are connected to soil moisture sensors and weather data, enabling them to water crops only when needed, thus optimizing water use.
   - ✓ **Irrigation Scheduling:** Advanced software and apps can help farmers schedule irrigation based on factors like soil moisture levels and weather forecasts, avoiding over-irrigation.
6. **Soil Health Monitoring:**
   - ✓ **Soil testing** is integral to precision agriculture. India has implemented initiatives to promote soil health management. Some key activities include:
   - ✓ **Soil Health Cards:** The government issues soil health cards to farmers, containing detailed information about soil nutrients and the recommended amount of fertilizers to apply.
   - ✓ **Remote Sensing and Satellite Imaging:** These technologies provide farmers with insights into soil composition and health, allowing for more informed decision-making regarding crop selection and fertilizer use.
7. **Mobile Applications and Platforms:** Mobile technology is crucial in disseminating information to farmers. Some prominent apps and platforms in India include:
   - ✓ **Agri-Tech Platforms:** These platforms provide data on weather, market prices, crop advisories, and real-time pest detection.
   - ✓ **Farmer-to-Farmer Networks:** Apps and platforms also provide a forum for farmers to share advice and experiences, fostering collaboration and knowledge sharing.
   - ✓ **Advisory Services:** Many apps give personalized farming advice based on inputs such as soil type, crop variety, and regional conditions.

Benefits of Precision Agriculture

1. **Increased Crop Productivity:** Precision agriculture allows farmers to apply the right amount of nutrients, water, and pesticides, resulting in better crop health and increased yields. By

optimizing inputs and practices, farmers can significantly improve productivity, even with limited resources.

2. **Resource Efficiency:** By using sensors and real-time data, farmers can optimize the use of water, fertilizers, and pesticides. This leads to a reduction in resource wastage and lower input costs, which is particularly important in regions where water and soil fertility are limited.
3. **Sustainability:** Precision agriculture practices support environmental sustainability by reducing over-application of chemicals, improving soil health, and conserving water. These practices also reduce the carbon footprint associated with traditional farming methods.
4. **Cost-Effectiveness:** While the initial investment in technology might be high, the long-term savings from more efficient farming practices—such as reduced fertilizer costs and lower water usagemake precision agriculture economically viable for many farmers.
5. **Climate Change Adaptation:** The technology enables farmers to adapt to the changing climate by providing accurate weather data and by predicting weather events that may affect crops, such as droughts or floods. This allows farmers to take preventative measures and plan their activities accordingly.

Challenges in the Adoption of Precision Agriculture

1. **High Initial Investment:**

   While precision agriculture offers long-term benefits, the initial costs of acquiring advanced technology (such as drones, sensors, and GPS systems) can be a barrier for small-scale farmers, especially in rural areas.

2. **Lack of Technical Knowledge:**

   Farmers, especially those in rural areas, often lack the technical expertise required to operate advanced equipment and interpret complex data. This gap in knowledge can impede the adoption of precision farming technologies.

3. **Inadequate Infrastructure:**

   In many rural parts of India, there is a lack of reliable internet connectivity, stable electricity, and access to digital devices, which are crucial for implementing precision agriculture solutions. This infrastructure gap limits the scalability of these technologies.

4. **Government Support and Policy Implementation:**

   While the Indian government has introduced several initiatives to support precision farming, the effectiveness of these programs depends on timely implementation and the reach of services. In many cases, farmers are unaware of government schemes or do not have easy access to them.

Government Initiatives and Support

1. **National Mission on Agricultural Extension and Technology (NMAET):**

   This initiative supports the dissemination of advanced agricultural practices, including precision farming, to farmers across India. The program includes training for farmers, subsidies for equipment, and advisory services on modern farming techniques.

2. **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY):**

   This scheme aims to improve water use efficiency in agriculture, promoting the adoption of micro-irrigation systems like drip irrigation and sprinklers.

3. **Soil Health Management and Soil Health Cards:**

   The government provides soil health cards to farmers, detailing the nutrient levels of their soil and recommending the correct types and amounts of fertilizers. This helps reduce the overuse of chemicals and supports more sustainable farming.

Conclusion

Precision agriculture is gradually gaining traction in India, and its adoption is expected to grow as technology becomes more affordable and accessible. By improving productivity, conserving resources, and reducing environmental impact, precision farming has the potential to play a significant role in making Indian agriculture more resilient and sustainable in the face of increasing challenges. Furthermore, government policies and growing access to technology will continue to drive the adoption of precision farming practices across the country. As India's farming community embraces these technologies, the future of agriculture in the country may see a shift towards more data-driven, efficient, and sustainable practices.

Volume: 04 Issue No: 12

AI-DRIVEN CROP MONITORING AND DISEASE DETECTION: TRANSFORMING INDIAN AGRICULTURE

Article ID: AG-VO4-I12-26

Ritik Kumar Maurya[a, b*], Dr. Radhe Shyam Maurya

[a]Department of Agronomy, College Of Agriculture Sciences, Uttaranchal P.g. College Of Bio-Medical Sciences & Hospital Dehradun-248001, Uttarakhand, India

[b]Assistant Professor-cum-Jr. Scientist (Agronomy) Bihar Agriculture University, Sabour

*****Corresponding Author Email ID**:** ritikmauryadehradun@gmail.com

Abstract

Agriculture is the backbone of India's economy, supporting over half of the population. However, it faces persistent challenges such as climate variability, pest infestations, and crop diseases, which significantly affect productivity and farmer incomes. Artificial Intelligence (AI) is emerging as a transformative technology, offering innovative solutions for real-time crop monitoring, precise disease detection, and resource optimization. By utilizing data from satellite imagery, drones, and sensors, AI systems provide actionable insights and predictive analytics, enabling farmers to address threats with unmatched accuracy. This article explores key AI-driven initiatives revolutionizing Indian agriculture. Tools like the Plantix app identify crop diseases through farmer-uploaded photographs, while Microsoft's pest prediction system uses weather and historical data to forecast outbreaks with high accuracy. Platforms such as Jio Krishi utilize satellite imagery to offer tailored recommendations for crop management. A case study on wheat monitoring in Punjab highlights AI's role in mitigating diseases like yellow rust, where satellite analysis and predictive models reduced input costs and boosted yields. While AI adoption holds immense promise, challenges remain. Limited data accessibility, inadequate rural infrastructure, and the need for farmer training pose significant barriers. Bridging the digital divide and strengthening collaborations among tech companies, research institutions, and government programs are crucial for scaling these solutions. As investments in agri-tech grow, AI is poised

to make Indian agriculture more resilient, profitable, and sustainable, addressing the sector's pressing challenges and ensuring long-term viability for millions of farmers

Introduction

Agriculture remains the backbone of India's economy, supporting the livelihoods of millions. Yet, the sector faces strong challenges: erratic weather patterns, pest infestations, and crop diseases continue to threaten productivity and farmer incomes. Traditional methods of tackling these issues often fall short, being time-consuming, labor-intensive, and less precise. Artificial Intelligence (AI) – a game-changing technology poised to revolutionize Indian agriculture. By harnessing the power of data, machine learning, and advanced imaging tools, AI enables farmers to monitor crops in real time, predict disease outbreaks, and address potential threats with incomparable accuracy. This fusion of technology and farming not only boosts efficiency but also ensures sustainable agricultural practices.

In this article, we explore how AI-driven crop monitoring and disease detection are transforming Indian agriculture. From real-world success stories to the challenges ahead, we delve into how these advancements hold the promise of a resilient, profitable, and digitally skilled farming future. India, an agrarian economy with over 50% of its population dependent on agriculture, faces persistent challenges like unpredictable climate changes, pest infestations, and crop diseases. These issues, if unaddressed, significantly impact crop yields and farmer incomes. Emerging technologies like Artificial Intelligence (AI) are proving transformative in addressing these challenges, enabling timely interventions and sustainable agricultural practices.

AI in Crop Monitoring and Disease Detection

AI leverages machine learning algorithms and computer vision to analyze vast amounts of data from satellite imagery, drones, and sensors. It identifies crop health issues, pest infestations, and nutrient deficiencies early, enabling farmers to take corrective actions. Key features of AI-driven systems include:

Real-Time Monitoring: AI-enabled drones and IoT devices capture high-resolution images, providing real-time updates on crop conditions.

Predictive Analytics: AI models forecast disease outbreaks and pest attacks based on weather patterns and historical data.

Precision Insights: AI identifies specific areas requiring intervention, optimizing resource use like water, fertilizers, and pesticides.

Examples of AI Projects in India

Plantix by PEAT:

This AI-powered mobile app identifies crop diseases through photographs taken by farmers. With over a million downloads in India, it has become a go-to tool for diagnosing and managing crop issues in real time.

Impact: Farmers in Andhra Pradesh and Telangana reported a significant reduction in losses due to early disease identification.

Microsoft AI for Agriculture:

In collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Microsoft uses AI to predict pest attacks in crops like cotton.

Case Study: In Maharashtra, the system provided pest forecasts with 80% accuracy, allowing farmers to plan effective interventions.

Punjab's Wheat Monitoring with AI:

AI-driven satellite analysis tracks wheat health in Punjab, identifying areas prone to diseases like rust. Collaborations with local agronomists ensure timely dissemination of advice to farmers.

Outcome: The program helped reduce yield losses in affected areas, boosting productivity and farmer earnings.

Jio Krishi Platform:

Reliance's agri-tech initiative uses AI to offer insights into crop growth stages and health conditions through satellite imagery.

Application: It supports farmers in states like Uttar Pradesh and Madhya Pradesh by providing actionable recommendations for improving yield.

Case Study: Wheat Yield Monitoring in Punjab

Punjab, the "Granary of India," heavily relies on wheat cultivation. Recently, AI models have been integrated with satellite data to monitor crop growth stages and identify threats like yellow rust. In a pilot project:

- Satellite images were analyzed to detect stress in wheat fields.
- AI predicted disease spread zones based on humidity and temperature patterns.

- Extension workers disseminated localized advice, enabling farmers to spray fungicides only where necessary.
- This initiative reduced input costs and prevented unnecessary pesticide use, improving environmental sustainability and farmer incomes.

Challenges and Future Scope

Despite these successes, challenges remain which includes :

Data Accessibility: Ensuring widespread availability of high-quality agricultural data.

Farmer Training: Bridging the digital divide and enhancing farmer literacy in using AI tools.

Infrastructure: Strengthening rural connectivity for real-time data processing.

With increasing investment in agri-tech and government support, AI's role in Indian agriculture is set to expand, promising sustainable and profitable farming practices for millions.

Conclusion

AI-driven crop monitoring and disease detection are revolutionizing Indian agriculture. By enabling precise interventions and improving resource efficiency, these technologies address pressing challenges faced by farmers. Collaborative efforts between tech companies, research institutions, and government initiatives will further enhance the scalability and effectiveness of these solutions, ensuring a resilient agricultural future for India.

AI in agriculture, crop monitoring, disease detection, Indian agriculture, AI-powered tools, precision farming, sustainable agriculture, pest management, real-time monitoring, predictive analytics, satellite imagery, agri-tech, Plantix, Microsoft AI for Agriculture, Jio Krishi Platform, wheat monitoring, yellow rust, farmer training, rural connectivity.

References

PEAT GmbH. (n.d.). Plantix - Your crop doctor. https://www.plantix.net

Microsoft India. (n.d.). AI for agriculture: Empowering farmers with pest predictions and improved crop management. https://www.microsoft.com/en-in

Reliance Jio. (n.d.). Jio Krishi: Revolutionizing agriculture with AI and satellite technology. https://www.jio.com

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). (n.d.). AI applications in Indian agriculture: Case studies on wheat monitoring. https://www.icrisat.org

Food and Agriculture Organization of the United Nations (FAO). (2021). Artificial Intelligence in agriculture: Innovation for food security. https://www.fao.org

Ministry of Agriculture & Farmers Welfare, Government of India. (2022). Digital agriculture: Strategies for transforming Indian farming. https://agricoop.nic.in

Singh, R., & Sharma, P. (2020). AI and precision farming in India: Opportunities and challenges. Journal of Agricultural Research, 45(3), 45-59.

Volume: 04 Issue No: 12

EXTENSION STRATEGIES FOR AUGMENTING SUSTAINABLE GREEN FODDER PRODUCTION

Article ID: AG-VO4-I12-27

Dr. S. Subash*

Senior Scientist

SRS of ICAR-National Dairy Research Institute, Adugodi, Bengaluru, Karnataka, India

Corresponding Author Email ID:* subashagri@gmail.com

Introduction

India is endowed with world's highest milk producing country and largest cattle holder in the world however the productivity per animals is less than 50% of the world's average. This is mainly due to poor level of nutrition and low genetic potential of milch animals etc. Half of the total losses in livestock productivity are contributed to by the inadequacy in supply of feed and fodder. At the same time there is a great demand for milk and milk products in our country due to increasing population, change in life style of people in food habits etc. As the land and water resources are rapidly shrinking there is huge demand for land for food in the country and there is a stiff completion for food resources between humans and animals. Fodder production and its utilization generally depend on the cropping pattern, climate, socioeconomic conditions and type of livestock maintained by the individual farmer. At present, there is a scarcity of land for fodder cultivation giving rise to a net deficit of 20% green fodder, 25% dry fodder and 32% concentrate mixture.

The present situation is further aggravated due to increasing growth of livestock particularly that of genetically upgraded, feed-intensive cross bred animals. The lack of availability and access to quality fodder resources is an important constraint in livestock production Forage-based economical feeding strategies are required to reduce cost of quality livestock products; as feed alone constitutes 60-70% of milk-production cost. At present, the country faces a net deficit of 35.6% of green fodder, 26% of dry-crop residues and 41% of concentrate feed ingredients as there is no practice of fodder production in rural areas in most of the areas and animals generally consume naturally grown grasses and shrubs which are prone to seasonal variations and thus results in fluctuation in fodder supply round the year affecting supply of milk round the year.

Fodder resources availability & its requirements Scenario

The fodder supply situation in India is extremely precarious and the gap between the fodder requirement and its availability is very wide. The chronic shortage of feed and fodder resources during the last few decades indicates that most of the livestock were underfed.

Table: Scenario of Feed and Fodder Availability and Future Requirement (MT)

Year	**Supply (MT)**		**Demand (MT)**		**Deficit as % of demand** (actual demand)	
	Green	**Dry**	**Green**	**Dry**	**Green**	**Dry**
1995	379.3	421	947	526	59.95 (568)	19.95 (105)
2000	384.5	428	988	549	61.10 (604)	21.93 (121)
2005	389.9	443	1025	569	61.96 (635)	22.08 (126)
2010	395.2	451	1061	589	62.76 (666)	23.46 (138)
2015	400.6	466	1097	609	63.50 (696)	23.56 (143)
2020	405.9	473	1134	630	64.21 (728)	24.81 (157)
2025	411.3	488	1170	650	64.87 (759)	24.92 (162)
Source: Draft Report of Working Group on Animal Husbandry and Dairying for Five-Year Plan (2002-2007, Govt. of India, Planning Commission, August-2001).						

It is obvious from the above table that deficit in green and dry fodder is increasing every year, while for concentrates/dry fodder, the gap is almost static. However, this gap is very critical and poses the greater challenge and concern about the future dairying activities. The major sources of fodder for feeding our livestock is from; 54% of the total fodder is met from crop residues, while 18% fodder is met from grasslands and only 28% fodder is met from cultivated fodder crops (Hegde, 2006). Prominent among the crop residues were paddy straw, wheat straw, stalks of sorghum, maize, pearl millet, groundnut, beans and grams. Although these crop reduces were considered as very valuable by the livestock keepers, there have been a lot of wastage in different parts of the country. Though some farmers are selling crop residues at a lower price, it is clear that there is no demand for fodder in certain agriculture-rich areas, while certain other regions are facing fodder shortage. This reflects on the need for developing necessary infrastructure to make best use of the available fodder resources, while aiming at enhancing the production further.

Constraints for Forage Production

The major constraint in green fodder production is low area under green fodder cultivation and remunerative returns from its cultivation and almost non existence of grazing land. The other specific constraints include;

1. **Small-holder Dairying:** While majority of the farmers are small holders, who are unable to use their holdings for fodder cultivation, for others, green fodder cultivation is a loss of opportunity to earn higher income by cultivating other high value cash crops. While the majority of the livestock rearers are being marginal and small holders owning over 90-95% livestock, are not able to devote their small holdings for cultivation of fodder crops, as their priority is to produce food grains.
2. **Reduced area under fodder crops:** The area under fodder cultivation has remained stagnant for a long period. Presently it is estimated that only 4.4% of the total cropped area is devoted to fodder production. This area has remained almost static since 2-3 decades and there is very little scope for increasing the area under fodder production due to the pressure on land holding to divert the area for other uses.
3. **Non availability of grazing lands:** The grazing pattern has created manifold problems in these pastures. Obnoxious weeds have invaded the pastures. Excessive and continuous grazing has severely damaged these lands. Further, due to the urbanization and other significant reasons like industrialisation, construction of buildings, occurrence of severe drought, etc the availability of grasses for the livestock in the open grazing areas is considerably reduced.
4. **Poor Management Practices:** Management practices play an important role in determining productivity of grasslands. Presence of inferior and unproductive grass species, lack of fertilizer application, and absence of legume component, improper cutting and indiscriminate grazing are some of the important factors responsible for poor productivity of grasslands.
5. **Huge livestock population:** As our country has possess the highest cattle population in the world, which is causing more harm than good as majority of our cattle population is low producing due to its inefficient management**.** This huge population and poor fodder availability has widened the gap between demand and supply of forage crops. It is a fact that considerable

fodder resources are wasted on maintenance of an excessive number of poorly fed and low yielding animals, which contributed to process of pasture destruction.

6. Low Profitability & poor marketing: Presently, growing of green fodder crops over other cash commercial crops is not very attractive as the returns from green fodder cultivation is very low due to its low productivity and also absence of marketing avenues especially for fodder crops on a commercial scale.

7. Non-availability good quality fodder seeds & technology: Though there are many agricultural research Institutions/ Universities are carrying out fodder related research and coming out with new varieties however much needed attention was not accorded to developing high yielding, multi-purpose, drought resistant, region specific fodder crops varieties along with optimised package of practices and hence there has not been any significant change in the status of forage supply in the country.

8. Lack of Extension Support: Lack of exclusive extension programmes for fodder cultivation promotion and absence of functional-synergy among the state development departments like Department of Agriculture and Animal Husbandry, non availability of quality fodder crop seeds and lack of access to improved fodder crops technologies, etc further affects the prospects of growing fodder crops.

Extension Strategies for increasing Fodder Production

To meet current level of livestock production and their annual population growth, strategies are needed to include measures that improve availability of quality fodder as well as for designing suitable models for fodder-based economic milk production. Better genetic resources of fodder crops, including grasses, have to be collected and conserved. And at a large- scale, food-fodder cropping systems need to be encouraged to provide balanced nutrition to livestock in the mixed farming situations. The specific extension strategy to promote the green fodder cultivation includes;

- Strengthening the extension education & services delivery mechanism at field level
- Promotion of extension programmes like fodder Mini-kit for growing fodder crops
- Creating awareness among the farmers about the importance of green fodders and efficient use of crop residues and about balance feeding for higher economical returns
- Increasing forage crop yields by adopting improved agronomic practices and improved seed production practices

- Improving profitability by developing necessary infrastructure to make best use of the available fodder resources though proper marketing
- On-farm evaluation of fodder technologies and promotion of fodder feed production
- Creating awareness on conservation strategies of fodder resources to meet its demand in lean season
- Promotion and adoption of food-fodder cropping system i.e Agri-horti-silvicultural system/ Horti-pastoral system/ Forage production on bunds & Wasteland
- Promotion and control of community grazing lands/pastures
- Functional linkage and convergence between the sate development departments for better promotion of fodder cultivation in the region
- Establishment of fodder banks for its efficient utilization
- Promotion of entrepreneurship in Peri-urban areas for fodder cultivation and its marketing
- Capacity-building and training to extension functionaries on fodder cultivation technologies

Conclusion

The economic viability of livestock husbandry is dependent on the genetic potential for production, good health care, balanced feeding of animals and efficient marketing of the produce. The Importance of forage production in maintaining nutritional status of livestock is highly imperative for significant progress in dairy development. As the supply of forage and feeds determine the profitability of livestock husbandry and livestock being the major source of livelihood for the rural poor, we need to set our priority to address the needs of small farmers by developing various forage production systems and improving the accessibility to improved fodder seeds, scientific technologies and its marketability for promising returns. Promotion of fodder crops cultivation needs to be accelerated through strong extension programmes and government policies aimed at improved availability of fodder resources for bring out the sustainable agricultural development.

References

Draft Report of Working Group on Animal Husbandry and Dairying for Five-Year Plan 2002-2007, Govt. of India, Planning Commission, August-2001.

Feed & Fodder Requirements for Milk Production in India. Accessed from http://www.love4cow.com/feedandfodder.htm

Hegde N.G., 2006. Livestock Development for Sustainable Livelihood of Small Farmers. CLFMA Souvenir: 50-63.

Meena, M. S., & Singh, K. M. 2011. Scenario and Strategies for Revitalizing Fodder Production Technologies". In Forage and Fodder Crops of India (pp. 348-356).

Volume: 04 Issue No: 12

INTEGRATED FARMING FOR ENHANCED LIVELIHOOD SECURITY

Article ID: AG-VO4-I12-28

***D. Sravanthi, A. Sai Kishore, N. Charitha, K. Naganjali and M, Ramprasad**
Agricultural College, Aswaraopet,
Professor Jayashankar Telangana Agricultural University (PJTAU), Telangana, India
*Corresponding Author Email ID: danamsravanthi@gmail.com

Introduction

Agriculture is the backbone of the Indian economy. Nearly 60% of the Indian population directly depends on agricultural activities as a source of livelihood. Indian agriculture is dominated by small and marginal farmers (86%), having only 50 % of the total arable land (1,80,888 thousand hectares Acc to Ministry of Agriculture and & Farmers Welfare, 2018-19). The fragmentation of land resources is posing a serious threat to future sustainability, food security, and profitability of Indian farming (Siddeswaran *et al.*, 2012). The Indian marginal and small farmers are mostly concentrating on cereal-based crop production with high risks of climate anomalies such as floods and droughts. Due to these aberrations, farmers are unable to get sufficient income to sustain their family (Kumar *et al.*, 2018).

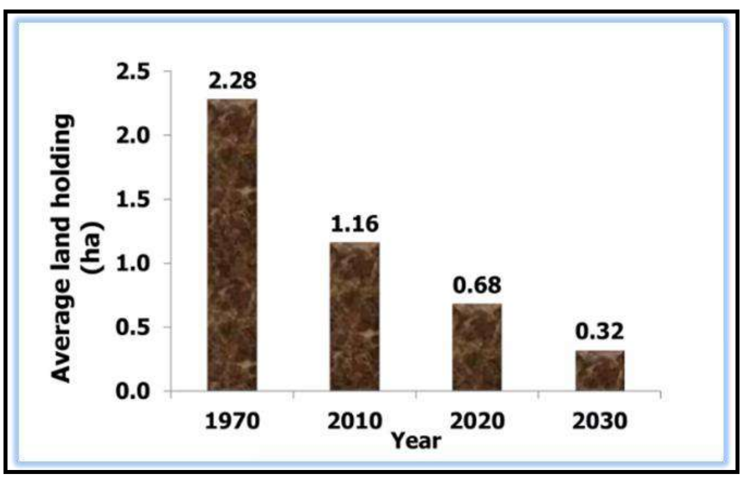


Fig. 1: Shrikage size of land holding (ha)

Agriculture is the mainstay of our economy, a way of life for millions of farm families. Land is a primary source of livelihood and a critical factor that shapes the livelihood strategies and resultant outcomes. India lives in its villages - this axiom is as true today as it was when the country became independent 68 years ago. Agriculture and allied activities support livelihoods of nearly 70 per cent of India's rural population.

What is IFS?

Integrated farming systems (IFS) entail a holistic approach to farming aimed at meeting the multiple demands (impart farm resilience, farmer livelihoods, food security, ecosystem services, and making farms adaptive and resilient, etc.,). IFS are characterized by temporal and spatial mixing of crops, livestock, fishery, and allied activities in a single farm. It is hypothesized that these complex farms are more productive at a system level, are less vulnerable to volatility and produce less negative externalities than simplified farms. Thereby, they cater the needs of small and marginal farmers, who are the backbone of agriculture in India. IFS have the potential to improve farm profitability (265%) and employment (143%) compared to single enterprise farms

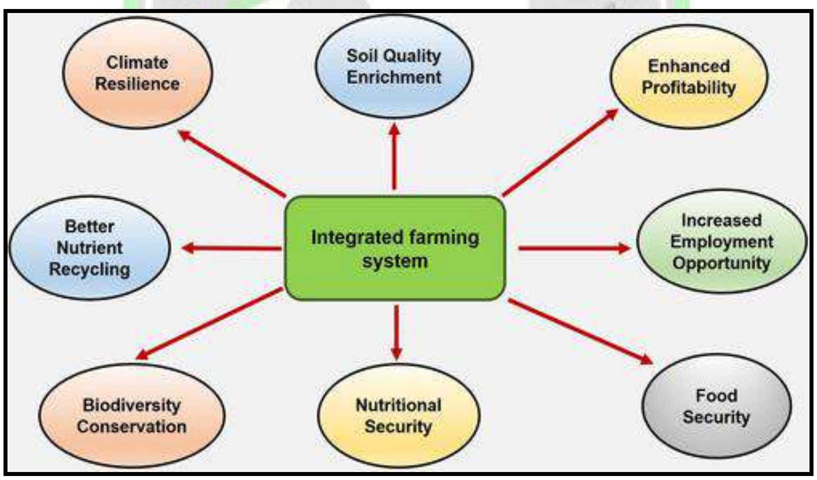


Fig. 2: Components of IFS

Different ecosystems

IFS under different agro-ecosystems

1. Rainfed
2. Irrigated
3. Hill and mountains

What is the need ?

Indian agriculture is known for its multifunctionalities of providing employment, livelihood, food, nutrient and ecological securities. But Agricultural growth in India is decelerating in recent years. The smaller share of agriculture in national GDP is getting distributed among a larger number of people who depend on agriculture for their livelihood and even credit. Integration of farm enterprises provides better livelihood in terms of increased food production, higher net income, reduced income imbalances and improved health, habitat, educational and social status. Therefore introduction of appropriate farming systems is going to be one of the important approaches to achieve better growth in agriculture and securing livelihoods of major segment of society. Livelihood security can be defined as "adequate flow of resources to meet the basic needs of the people, access to social institutions relating to kinship, family and neighborhood, village and gender bias free property rights required to support and sustain a given standard of living". The outcomes of livelihood security include Economic security, Food security, Educational security, Health security, Habitat security and Social network security.

IFS for livelihood security

- ✓ Household Livelihood Security has been defined as adequate and sustainable access to income and resources
- ✓ To meet basic needs (including adequate access to food, potable water, health facilities, educational opportunities, housing, and time for community participation and social integration) (Frankenberger 1996).
- ✓ One of the main reasons for most of the farmers suicide cases was not having any other option of livelihood generation besides doing crop farming (Jadhav, 2008)
- ✓ In a normal year crop production generate the income for 90-120 days, while for the remaining period, rural work force remains unemployed (Chauhan and Singh, 2007)
- ✓ Indian agriculture is known for its multifunctionalities of providing employment, livelihood, food, nutrient and ecological securities.
- ✓ But Agricultural growth in India is decelerating in recent years.
- ✓ The smaller share of agriculture in national GDP is getting distributed among a larger number of people who depend on agriculture for their livelihood and even credit.

- ✓ Integration of farm enterprises provides better livelihood in terms of increased food production, higher net income, reduced income imbalances and improved health, habitat, educational and social status.
- ✓ Therefore introduction of appropriate farming systems is going to be one of the important approaches to achieve better growth in agriculture and securing livelihoods of major segment of society.
- ✓ Therefore, it was important to select dimensions, which were representative indicators of all these sectors of human life.
- ✓ The availability of authenticated literature and through discussion with experts in relevant field played an important role in the identification of these dimensions.
- ✓ Each of the dimensions was operationally defined for its quantification and the measurement

Livelihood is always more than just a matter of finding or making shelter, transacting money and preparing food to put on the table or exchange in the market place, It is equally a matter of the ownership and circulation of information, the management of social relationships, the affirmation of personal significance and group identity and the interrelationship of each of these tasks to the other. All these productive tasks together constitute a livelihood. For an anthropologist, livelihood is an umbrella concept, which suggests that social life is layered and that these layers overlap (both in the way people talk about themselves and the way they should be analyzed). This is an important analytical feature of the notion of livelihoods (Wallman, 1984). Livelihood is the means for people use to support themselves, to survive, and to prosper. It is an outcome of how and why people organize to transform the environment to meet their needs through technology, labour, power, knowledge, and social relations. Livelihoods are also shaped by the broader economic and political systems within which they operate. In general, almost half of the world's population does not have the socio-economic and political means to realize their economic and social rights. One of the major causes of the poverty is the lack of viable livelihoods in the developing world. Livelihood is also about creating and embracing new opportunities.

While gaining a livelihood, or attempting to do so, people may, at the same time, have to cope with risks and uncertainties, such as

- Erratic rainfall,
- Diminishing resources
- Pressure on the land
- Changing life styles
- Kinship networks,
- Exploitative markets,
- Increasing food prices - inflation
- National and international competition.

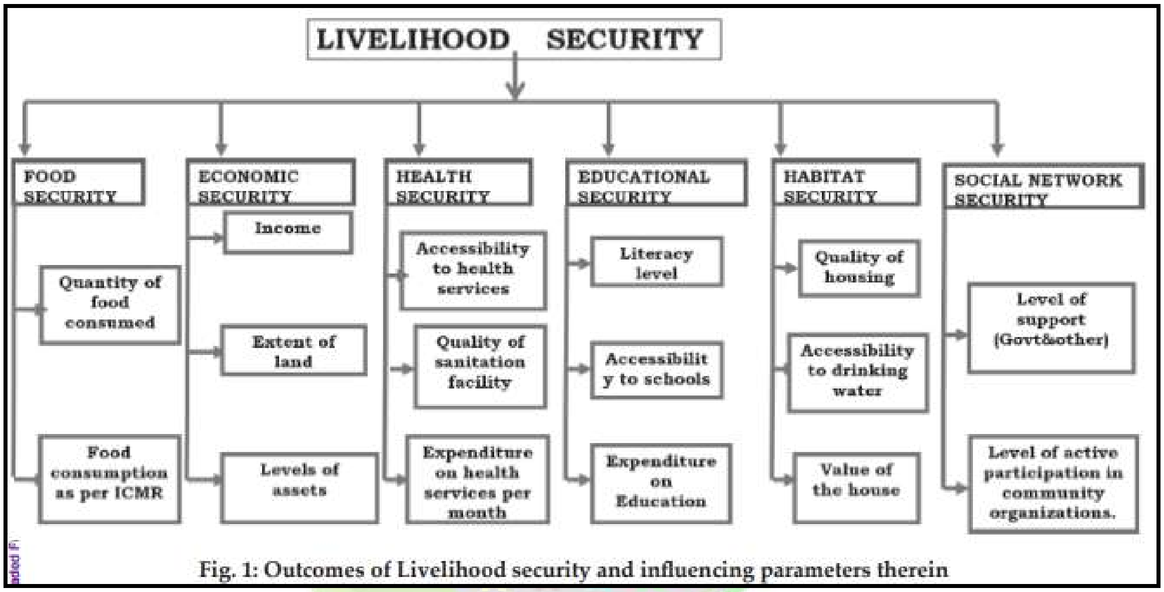


Fig. 3: Outcomes of livelihood security and influencing parameters

These uncertainties, together with new emerging opportunities, influence how material and social resources are managed and used and on the choices people make. Integration of various enterprises in a farm ensures recycling of farm wastes and utilizing all the available resources most economically and efficiently. It also aims at working out appropriate combinations of farm enterprises, resources, practices and methods. In recent years, land-based livelihoods of small and marginal farmers are increasingly becoming unsustainable since the land has not been able to support the family's food requirements and fodder for their cattle. As a result, rural households are forced to look at alternative means for supplementing their livelihoods.

Integrated farming is a sustainable and effective tool for improving rural economy due to its cumulative cost effectiveness, low investment and higher profitability. It optimizes the farm productivity per unit area through incorporation of recycling wastes and residues from one farming system to the other with due environmental consideration. Indian farming community is dominated by small and marginal farmers and hence Integrated Farming System (IFS) approach has been identified as the way-out for providing income and employment to the millions farmers and farm women engaged in agriculture sector. It has immense potential to ensure livelihood as well as income security to the persons engaged through any component of IFS (Minakshi *et al.*, 2019). The income from average farmers from cropping alone is hardly sufficient to sustain their family. social impacts like care about workers health, safety and welfare also be the part of any sustainable system (Nain *et al.*, 2020). Hence the present study was undertaken with an objective to study the sustainable. The income from average farmers from cropping alone is hardly sufficient to sustain their family. social impacts like care about workers health, safety and welfare also be the part of any sustainable system (Nain *et al.*, 2020). Hence the present study was undertaken with an objective to study the sustainable. The sustainable livelihood security has multidimensional aspects. It includes environmental security, permanent asset creation, food and nutritional security, input recycling, economic security, financial security, occupational security and social security. Therefore, it was important to select dimensions, which were representative indicators of all these sectors of human life.

$$I_i = \frac{\text{Obtained score}}{\text{Maximum obtainable score}} \times 100$$

where, i= (A, B,.....H) dimensions

$$\text{Sustainable Livelihood Security Score (I)} = \frac{A+B+C+D+E+F+G+H}{8}$$

Where,

A = Environmental Security,

B = Permanent asset creation,

C = Food and nutritional security,

D = Input recycling,

E = Economic security,

F = Financial security,

G = Occupational security and

H = Social security.

The final standardized index measuring the Sustainable Livelihood Security of the farmers practicing IFS was used for the present investigation. The sustainable livelihood security scores ranges from 0-100

Constraints in adoption of Integrated Farming Systems

- Labour shortages, especially where the family size is small, which effectively prevented them from adopting integrated farming techniques,
- Lack of secure land rights and disincentives to adopting integrated farming resulting from government subsidies, credits for fertilizers, and herbicides.
- Procuring improved breeds of livestock, timely availability of fish seed and fish feed,
- Low cost and energy efficient device for pumping out water for irrigation, information on government schemes and credit support from financial institutions.
- As the IFS practicing farmers were scattered over the region it may be desirable that cluster wise IFS farmers associations

References

Siddeswaran, K., Sangetha, S. P. and Shanmugam, P. M. 2012. Integrated farming system for the small irrigated upland farmers of Tamil Nadu. *Extended Summaries: 3rd International Agronomy Congress.* 26-30.

Chauhan, R. K. and Singh, S. P., 2007. Agricultural unemployment and underemployment in India: A review. *Journal of Farm Sciences*. 1(1): 12-26.

Kumar, S., Bhatt, B. P., Dey, A., Shivani, A, Kumar, U., Idris, M., Mishra, J. S. and Kumar, S. 2018. Integrated farming system in India: Current status, scope and future prospects in changing agricultural scenario. *Indian Journal of Agriculture Sciences.* 88(11): 13-27.

Jadhav, N. 2008. Farmer's suicide and debt waiver an action plan foragricultural development of Maharashtra. Report submitted to the Government of Maharashtra, July, 2008.

Frankenberger, T. 1996. Measuring household livelihood security: an approach for reducing absolute poverty. Food Forum, No.34. Washington, DC, USA. Wallman, S. 1984, Eight London households, London Tavistock.

Minakshi, M., Khare, N. K. and Singh, S. R. K. 2019. Assessing Integrated Farming System Models Apropos Employment Generation Potential in Madhya Pradesh. *Indian Journal of Extension Education.* 55(3): 65-68.

Nain, M. S., Singh, R. and Mishra, J. R. 2020. Relevance of good agricultural practices in organic production systems. *Journal of Community Mobilization and Sustainable Development*. 15(2): 306-314.

Wallman, S. 1984. Eight London Households. London: *Tavistock Publications*: 224-230.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

INSIGHT MECHANISM OF CYTOPLASMIC MALE STERILITY AND FERTILITY RESTORATION

Article ID: AG-VO4-I12-29

Dr. K. Nandhini*

Assistant Professor (Plant Breeding and Genetics)

Regional Agricultural Research Station, Pattambi, Kerela, India

*Corresponding author Email ID: nandhini.kemparaj@gmail.com

Introduction

Male sterility is the phenomenon, where the male reproductive is non-functional and aids in cross pollination. Male sterility was first observed by Koelrouter in 1763. Based on genetic control male sterility is classified as genetic male sterility, cytoplasmic male sterility, and cytoplasmic genetic male sterility. Universally, CMS is observed in around 200 species. However, insight mechanism in regulating sterility and restorer of fertility (Rf) gene is challenging. Many scientists have reported that male sterility is controlled by mitochondrial genome, but sterility is counteracted restorer gene resides in nuclear genome.

Male sterile lines are used as female in hybrid breeding to ensure cross pollination, while the presence of *Rf* gene is essential in male parent to ensure fertility in offsprings and producing viable seeds (Budar *et al*., 2003). Eventually, various *Rf* gene has been developed in rice naturally to maintain reproductive success, explains the adaptive strategies of plants. These restorer genes arisen from various molecular mechanism *viz*., gene duplication, mutation and recombination.

Heterosis Breeding in Rice

Heterosis breeding can yield 15–50% more than inbred varieties (Tester and Langridge, 2010). However, hybrid seed production through conventional method requires proper emasculation, which is tedious process. On other hand, CMS (cytoplasmic male sterility) and EGMS (environmentally sensitive genic male sterility) lines do not require emasculation, making them ideal female lines for hybrid seed production. Subsequently, CMS-based hybrid technology was developed for many other crops, including rice to exploit heterosis. According to Chase, (2007) understanding the evolution of fertility restorer gene is essential in improving hybrid rice production also advances in crop breeding.

Cytoplasmic Male Sterility

CMS system is a three-line breeding system which includes, male sterile line, maintainer line and restorer line. Here, A line has defective male sterile cytoplasm and lacks functional nuclear restorer gene thereby used as female parent in hybrid seed production. B line a maintainer line possesses fertile cytoplasm, isogenic to A line but lacks restorer gene also helps to maintain A line. R line a restorer line, restores male fertility of A line used as male parent in heterosis breeding generating hybrid vigour Fig.1 (Schnable and Wise, 1998).

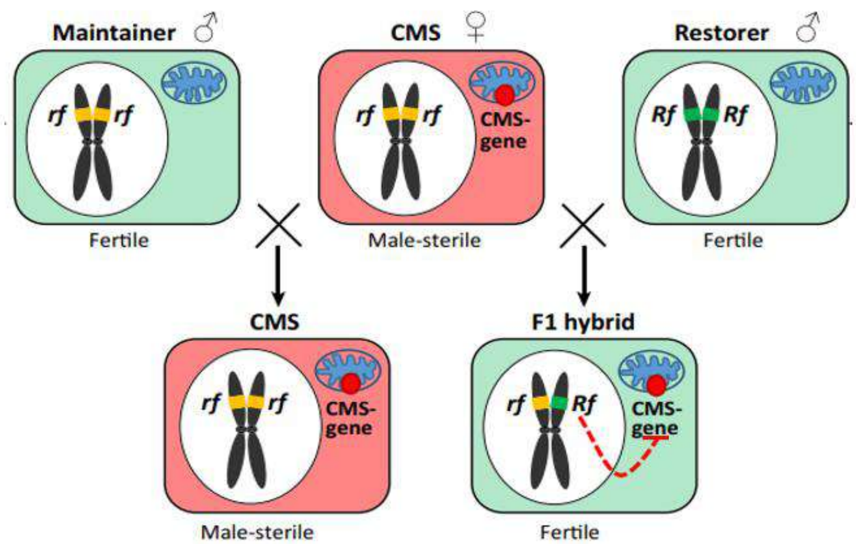


Fig.1 Cytoplasmic Male Sterility Lines Used in Three-Line Hybrid Seed Production

Inheritance of male sterility in CMS system is maternally controlled (Chen and Liu, 2014). CMS are developed either through natural or artificial mutation. At the same time there quite diverse *Rf* loci is also observed, different *Rf* gene interacts and corrects the defective cytoplasm in a unique way (Yamagishi and Bhat, 2014).

Characteristics of *Rf* genes

First *Rf* gene was reported by cui *et al.* (1996) in T-CMS maize, demonstrating these genes counter interacts the harmful effect caused by sterile cytoplasm. Many *Rf* s cloned were identified as PPR genes. In rice 450 genes encodes PPR proteins half targets mitochondria and quarter in chloroplast (Chen *et al*. 2018). These proteins play a major role in post transcriptional process. While some other *Rf* genes do not represent PPR protein, indicating complex restoration pathway. Most of these *Rf*s products are translocated and nullifies the deterioration created by CMS in mitochondria (Toriyama, 2021).

_Rf_ genes and PPR proteins

Most of the *Rf* genes in rice encodes PPR proteins except *Rf2* and *Rf17*. Tandem repeats of 35 amino acid units in PPR proteins is defined as PPR motifs. They widely involved in RNA processing *viz.*, editing, cleavage, stabilization, and translational activation within mitochondria and plastids. According to Cheng *et al.* (2016) 5^{th} and 35^{th} amino acids of these PPR motifs are mainly involved in nucleotide recognition.

Rf1 gene encodes 791 amino acid PPR protein, were signal sequence targets mitochondria. Additionally, they bind to intergenic region of atp6-*orf*79 for RNA processing (Kazama *et al*. 2008). However, in BT-CMS *orf*79 is co-transcribed with atp6 in mitochondria. While, *Rf1* cleaves this pre mRNA, generating 0.45 kb of orf79 RNA and 1.5 kb atp6 RNA (Kazama *et al*. 2008; Wang *et al*. 2006). However processed *orf*79 is not translated, thereby stops the action of these gene and restores the fertility (Wang *et al*. 2006).

In Nippon bare RF_1B overcomes *orf*79 production through post-transcriptional degradation of *orf*79 transcript (Wang *et al*. 2006). *Rf* 5 in HL - CMS encodes 791 amino acid protein and these transcript works together with GRP162 a glycine rich protein. Both acts combinedly, interacts and cleaves atp6-*orf*H79. *Rf6* for HL-CMS encodes an 894-amino acid protein with 20 PPR motifs. They are associated with localized hexokinase 6 in mitochondria, which facilitates processing of atp6-*orf*H79 (Huang *et al*. 2015).

RT98C a restorer line restores various CMS type at the same time have high similarity with seven other *Rf* like PPR genes. These genes mostly interact with different mitochondrial transcript. According to Igarashi *et al*. (2016), members of *Rf* – PPR cluster over comes the effect of newly emerged mitochondrial CMS-genes, thereby new *Rf* gene for different CMS system are evolved.

Four Models explaining CMS mechanism

Mitochondrial and nuclear interaction demonstration in various crop for CMS/*Rf* system supports four models: Cytotoxicity model, energy deficiency model, aberrant programmed cell death and retrograde regulation model.

a. Energy Deficiency model

This model states that the CMS protein produces mitochondrial deficiencies or affect membrane integrity causing proton leakage and low ATP production, thereby high energy demand for anther development is not satisfied. Sporophytic and gametophytic cells of anther urge for more energy than other organ. Lee and Warmke reported that, this need is satisfied by rapid division of mitochondria in anther cell, while in CMS they are suppressed due the CMS protein

CMS G in sugar beet follows energy deficiency model. Here, two mutated protein (extended NAD9 and truncated COX2) explains association between mtETC defect and CMS protein. In pepper (Ji *et al.*, 2013) CMS – Peterson, *orf* 507 co transcribes with cox2, leading to cytochrome c oxidase inactivity in male sterile line. Likewise, CMS -HL in rice exhibits low ATP and NADPH level in anther due to CMS protein by impairing the activity of complex III.

b. Cytotoxicity model

Here, CMS protein specifically produce toxins and kills male reproductive system. According Wang *et al.*, (2006) reported that in CMS – Boro II cytoplasm *orf*79 co transcribed with *atp6* and encodes cytotoxin peptide that specifically accumulates in microspore leading to male sterility. several such examples are reported in different crop Table 1.

Table 1. CMS protein that exhibits cytotoxicity model in various crops.

Crop	CMS type	Cytotoxin transcript	Protein Property	Reference
Maize	CMS – T	URF13	13-kDa toxic membrane protein	Dewey *et al.*, (1987)
Sunflower	CMS – PET 1	ORF522	15-kDa toxic membrane protein	Hans Köhler *et al.*, (1991)
Radish	CMS – O*gu*	ORF138	membrane protein	Duroc *et al.*, (2005)
Brassica	CMS – *Hau*	ORF138	Toxic protein	Jing Bing *et al.*, (2012)
Rice	CMS – WA	WA 352	Membrane protein	Luo *et al.*, (2013)

Most of these proteins are transmembrane protein and hydrophobic with 10–35-kDa, a specific property of cytotoxin protein. According to Leving (1993), in this model male abortion occur as result of mitochondrial dysfunction in sporophytic or gametophytic cell of anthers due to respective CMS protein.

c. Aberrant Programmed Cell Death Model

PCD in plants are like apoptosis where nuclear DNAs are fragment controlled through signals from mitochondria. Release of cytochrome *c* into cytoplasm from mitochondria followed by overproduction of ROS act as major signal to activate PCD in plants (Liu *et al.* 1996). Development of male gametophyte depends on proper degeneration of tapetum cell. As a result, delayed or premature PCD in tapetal cells leads to male sterility (Kawanabe *et al.* 2006).

Premature PCD of tapetal cells was noticed in sunflower CMS -PET 1 system, thereby cytochrome *c* is released early in cytosol. While in CMS -WA of rice, CMS protein accumulates specifically in microspore further interacts with *os*COX11 which is a negative regulator of PCD (Luo *etal.* 2013). Substantially, inhibits the function of COX11 therefore cytochrome *c* is released in advance into cytoplasm. Whereas, in CMS – HL of rice abnormal PCD was noticed in anthers which assist over production of ROS (Li *et al.* 2004).

d. The Retrograde Regulation Model

In CMS -CW rice, *Rf 17* encodes Retrograde – Regulated Male Sterility (RMS) a mitochondrial protein. Through retrograde signal expression of *rf* 17 is upregulated while it is not so in *Rf 17.* Subsequently increased RMS expression supresses pollen germination and leads to gametophytic sterility (Fujii and Toriyama, 2009). In carrot CMS lines, nuclear MAD- box genes expression is regulated by retrograde signalling from mitochondria, where they are involved in malformation of reproductive organs (Linke *et al.*, 2003). Usually, various CMS system is complex in nature, involving different model in a single CMS mechanism.

Mechanism for CMS Restoration

As mentioned previously any mechanism that supresses the detrimental effect of CMS protein restores the fertility. This can be achieved at different molecular level they are as follows:

a. Cytoplasmic Male sterility Restoration at Genomic level

Mitochondrial genome is highly diverse due to prominent variation in structure and copy number of DNA molecules. Occasional, Substoichiometric shifting in copy number of subgenomic molecule of CMS gene resulting in spontaneous reversion to fertility. In common bean CMS – Sprite sterility is induced by *PVS* sequence detected downstream of *atp1*(Jhons *et al.*, 1992). The respective sequence activity influenced in presence of dominant nuclear gene *Fr.* Accordingly, most of the CMS mitochondrial genome turned into normal one. This was first system reported explaining the restoration at genomic level. Similarly, substoichiometric shifting is also reported in CMS A1 pearl millet. Here, subgenomic molecule *cox1-1-2* junction region is boosted to 10-fold resulting in fertility restoration (Feng *et al.* 2009).

b. Cytoplasmic Male Sterility Restoration at Translational or Post Translational level

In some cases, fertility restoration depends at translational or post translational level. In maize CMS – C restoration act at protein level (Dewey *et al.,* 1991). Similarly in CMS – Sprite of common bean restorer gene (*Fr2*) suppresses the CMS protein level. On the other hand, in rice CMS -WA, restorer gene restricts the accumulation WA-352 protein in anthers. While, in CMS-LD rice translates a glycine rich protein which act at protein level.

c. Cytoplasmic Male Sterility Restoration at Posttranscriptional Level

Posttranscriptional modification such as editing, splicing, and cleavage is noticed in mitochondrial and chloroplast transcript. According to 124 cytidine (C) residues are changed to uridine in organelles particularly in mitochondria. From several expression and sequencing analyses concluded that various CMS transcript undergoes editing, polyadenylation, cleavage, and degradation mediated by Rf gene products (Table 2).

Table 2. CMS gene that undergo Post transcriptional process in various crop adopted from (Chen and Liu, 2014)

Crop	CMS - Type	RNA Transcript	Post transcriptional process
Sorghum	CMS-A3	*Orf-107*	Degradation of *Orf-107*
Sunflower	CMS-PET1	*Orf-522*	Polyadenylated
Maize	CMS -T	urf13-orf221	Reduce abundance of *urf 13* fragment
Brassica	CMS- pol	*Orf 224- atp6*	*Orf 224* degraded
Rice	CMS-BT	B-atp6-orf79	Modified cleavage of *Orf 79* not translated
Rice	CMS-HL	atp6-orfH79	Requires adaptor for proper cleavage
Rice	CMS -WA	rpl5-WA352	Degrades and reduces the abundance

Conclusion

Fertility restorer genes play a vital role in restoring male fertility in cytoplasmic male sterile (CMS) lines in rice. The correlation between sequence variation and fertility restoration efficiency provides insights into the underlying molecular mechanisms that govern the functional diversity of Rf genes/ Rf-like proteins. The utilization of Rf genes/ Rf-like protein diversity holds immense promise for marker-assisted breeding and the genetic improvement of hybrid rice varieties. As we face global challenges in food security and agricultural sustainability, understanding the evolutionary dynamics of *Rf* genes enables the development of more robust and productive hybrid rice varieties, capable of thriving in diverse environmental conditions. Hence, a comprehensive study of the evolutionary pathways of Rf genes, in conjunction with CMS genes, is essential for optimizing hybrid rice breeding strategies and ensuring the continued success of rice cultivation worldwide.

References

Budar, F., Touzet, P., De Paepe, R., 2003. The nucleo-mitochondrial conflict in cytoplasmic male sterilities revisited. *Genetica* 117, 3–16.

Chase, C.D., 2007. Cytoplasmic male sterility: a window to the world of plant mitochondrial–nuclear interactions. *Trends Genet*. 23, 81–9.

Chen, G., Zou, Y., Hu, J., and Dign, Y. 2018 Genome-wide analysis of the rice PPR gene family and their expression profiles under different stress treatments. *BMC Genomics* 19: 720.

Chen, L. and Liu, Y.G. 2014. Male sterility and fertility restoration in crops. *Annu. Rev. Plant Biol.* 65, 579–606.

Cheng, S., Gutmann, B., Zhong, X., Ye, Y. *et al*. 2016. Redefining the structural motifs that determine RNA binding and RNA editing by pentatricopeptide repeat proteins in land plants. *Plant J* 85: 532–547.

Huang, W., Yu, C., Hu, J., Wang, L., Dan, Z. *et al.* 2015. Pentatricopeptide-repeat family protein RF6 functions with hexokinase 6 to rescue rice cytoplasmic male sterility. *Proc Natl Acad Sci USA* 112: 14984 –14989.

Igarashi, K., Kazama, T., and Toriyama, K. 2016. A gene encoding pentatricopeptide repeat protein partially restores fertility in RT98-type cytoplasmic male sterile rice. *Plant Cell Physiol* 57: 2187–2193.

Ji, J., Huang, W., Yin, C., & Gong, Z. (2013). Mitochondrial cytochrome c oxidase and F1Fo-ATPase dysfunction in peppers (Capsicum annuum L.) with cytoplasmic male sterility and its association with orf507 and Ψatp6-2 genes. *International journal of molecular sciences*, *14*(1), 1050-1068.

Kawanabe T, Ariizumi T, Kawai-Yamada M, Uchimiya H, Toriyama K. 2006. Abolition of the tapetum suicide program ruins microsporogenesis. Plant Cell Physiol. 47:784–87

Kazama, T., Nakamura, T., Watanabe, M., Sugita, M., and Toriyama K. 2008. Suppression mechanism of mitochondrial ORF79 accumulation by Rf1 protein in BT-type cytoplasmic male sterile rice. *Plant J* 55: 619–628.

Luo D, Xu H, Liu Z, Guo J, Li H, et al. 2013. A detrimental mitochondrial-nuclear interaction causes cytoplasmic male sterility in rice. Nat. Genet. 45:573–77.

Schnable, P.S and Wise, R.P. 1998. The molecular basis of cytoplasmic male sterility and fertility restoration. *Trends Plant Sci*. 3:175–80.

Tester, M., and Langridge, P. 2010. Breeding technologies to increase crop production in a changing world. *Science* 327:818–22.

Toriyama, K. 2021. Molecular basis of cytoplasmic male sterility and fertility restoration in rice. *Plant Biotech.* 38(3): 285-295.

Wang, Z., Zou, Y., Li, X., Zhang, Q., Chen, L., Wu, H. *et al*. 2006. Cytoplasmic male sterility of rice with boro II cytoplasm is caused by a cytotoxic peptide and is restored by two related PPR motif genes via distinct modes of mRNA silencing. *Plant Cell* 18: 676–687.

Volume: 04 Issue No: 12

REVOLUTIONIZING NUTRITIONAL SECURITY THROUGH INNOVATIONS IN FINGER MILLET VALUE-ADDITION

Article ID: AG-VO4-I12-30

Asish K. Binodh [1*], Sugitha Thankappan [2] and Amaravel, M [3]

[1] Department of Genetic and Plant Breeding, Tamil Nadu Agricultural University, Coimbatore-3

[2] School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore – 641114, Tamil Nadu, India

[3] Division of Genetics and Tree Improvement, ICFRE-Institute of Forest Genetics and Tree Breeding, Coimbatore-641002, Tamil Nadu, India

*Corresponding Author Email ID: asish@tnau.ac.in

Abstract

Finger millet (Eleusine coracana), a nutrient-rich ancient grain, is gaining prominence for its role in enhancing food security and promoting healthy eating. This article highlights the growing interest in value-added finger millet products, including flour, snacks, baby foods, and innovative fusion items like pasta. These products provide significant health benefits, such as high levels of dietary fiber, calcium, iron, and essential amino acids, making them attractive to health-conscious consumers. The expanding market for value-added millet products is also creating new economic opportunities for farmers and entrepreneurs through small-scale processing, product innovation, and wider market access. Incorporating finger millet into modern food systems holds promise for improving public health, combating malnutrition, and fostering sustainable agricultural practices, addressing both present and future nutritional demands.

Keywords: entrepreneurs, value-added products, economic opportunities

The Rising Importance of Finger Millet and Its Value-Added Products

Finger millet (Eleusine coracana), also known as Ragi, is an ancient grain that has recently gained considerable attention due to its impressive nutritional profile and versatility. Originating from Africa and widely cultivated in parts of Asia, finger millet is rich in essential nutrients, including dietary fiber, calcium, iron, and essential amino acids. Its resilience to adverse climatic conditions makes it an important crop for promoting food security. In the context of rising health consciousness and a focus on nutritious, plant-based diets, value-added products from finger millet are becoming increasingly popular, driving both economic and nutritional benefits. This article explores some of the prominent value-added products made from finger millet, highlighting their benefits and the emerging opportunities for local farmers and entrepreneurs.

Finger Millet Flour: A Nutrient-Dense Base for Countless Recipes

The most basic and commonly used value-added product of finger millet is its flour. Finger millet flour, or Ragi flour, is naturally gluten-free, making it an ideal ingredient for those with celiac disease or gluten sensitivities. It is often used to prepare various traditional dishes like porridge, roti, and dosa, particularly in Southern India. Beyond traditional uses, finger millet flour is now gaining traction as an ingredient in modern baked goods such as bread, cookies, and cakes. The health-conscious market is increasingly seeking alternatives to refined wheat flour, and finger millet flour, with its high calcium content and low glycemic index, fits this need perfectly.

Companies are also promoting finger millet flour in ready-to-use mixes for instant dosa, idli, and pancake batters. These mixes are convenient for consumers, driving their popularity and providing an opportunity for farmers to obtain a fair value for their crops. A recent study highlighted that incorporating finger millet into daily diets significantly improved calcium intake in children and women, demonstrating its immense potential for addressing micronutrient deficiencies (Jindal et al., 2023).

Finger millet flour is also used in value-added baked goods such as muffins, brownies, and pancakes, which cater to both traditional tastes and modern culinary preferences. This diversity has helped finger millet flour establish a significant presence in both local and international markets, supporting healthier eating habits among consumers.

Finger Millet-Based Snacking: Meeting the Demand for Healthy Snacking

The growing demand for healthy snacking options has led to a rise in the production of finger millet-based snacks. Snacks such as Ragi chips, Ragi crackers, and millet-based granola bars are becoming popular, particularly in urban areas. These snacks are typically baked or minimally processed, making them a healthier alternative to fried, high-calorie snacks. Finger millet's low glycemic index and high dietary fiber help regulate blood sugar levels, making these snacks particularly attractive to diabetic and health-conscious individuals. Ragi malt is another popular product in this category, often sold in powder form as an instant health drink mix. With its rich nutritional profile, including high levels of iron and protein, Ragi malt is an excellent choice for all age groups, particularly children and the elderly. Studies have shown that Ragi malt is beneficial for maintaining bone health and improving overall stamina (Harshitha and Jayaram, 2019). Finger millet-based snacks are also available as puffed and spiced varieties, offering a tasty yet nutritious snacking experience. These options are especially popular with younger generations, as they combine flavor with the health benefits of traditional grains.

Ragi Ball

Ragi Muffins

Ragi Laddoos

Ragi Pasta

Ragi Cookies

Ragi Crackers

Ragi Cake

Ragi Chikkis

Nutritional Value of Value-Added Finger Millet Products (Sharma and Yamer, 2022)

Product	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Fiber (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)
Biscuits	790.8	112.9	9.6	33.5	1.6	156.2	186.2	3.2
Muffins	829	115.34	11.1	35.94	1.94	260.3	256.4	3.48
Crackers	451.5	76.6	11.3	12	2.5	194.3	372.8	5.9
Laddoos	1110	83.9	18.4	79.03	9.3	246.6	427.6	5.02
Chikkis	1075	124.2	23.7	53.7	2.9	204	458.3	6.6

Finger Millet Pasta and Noodles: Fusion Foods for the Health-Conscious

To appeal to the younger generation and to cater to changing dietary preferences, food manufacturers have started to develop innovative products like finger millet pasta and noodles. These products blend traditional grains with contemporary formats, allowing health-conscious consumers to enjoy their favorite meals guilt-free. Finger millet pasta and noodles combine the nutritional benefits of millet with the convenience of easy-to-cook food items, providing an excellent source of energy, dietary fiber, and micronutrients.

This shift towards nutritious pasta and noodles also helps counter the growing concerns of childhood obesity, as finger millet products contain significantly more fiber and lower sugar content compared to refined wheat products. The increasing demand for functional foods with a positive health impact has positioned finger millet pasta as a promising product in the market (Kaur et al., 2024).

Finger millet-based pasta and noodles are also increasingly being incorporated into school meal programs, helping to ensure that children receive nutrient-dense foods that promote healthy growth and development.

Finger Millet in Baby Foods: Tackling Malnutrition

Finger millet is increasingly used in baby food formulations due to its high calcium, iron, and essential amino acid content. Ragi porridge is a traditional weaning food in many parts of India, and now commercial baby food products are incorporating finger millet to provide a nutritious, easily digestible meal for infants. Such formulations are especially important for combating malnutrition in rural areas, as they provide essential nutrients that promote healthy growth and development in children (Srivastava and Arya, 2021). Finger millet-based baby cereals are gaining popularity among urban mothers who want nutritious and safe weaning foods for their infants. The natural digestibility of finger millet makes it an excellent choice for developing strong bones and overall physical development in young children.

Opportunities for Farmers and Agripreneurs

The increasing consumer awareness of health and nutrition has paved the way for various finger millet value-added products to enter mainstream markets. This has created significant opportunities for farmers and entrepreneurs. Local farmers can enhance their income by venturing into the production of value-added products, such as flour, snacks, and baby foods, rather than selling raw millet at lower prices. Training programs and government initiatives aimed at promoting millets and establishing millet processing units have further supported this trend.

Small-scale entrepreneurs can benefit from the rising demand for millet-based products by creating innovative snacks, health drinks, and baked goods that cater to modern consumers. Collaboration with retailers and e-commerce platforms has also enabled these products to reach a wider audience, increasing consumer accessibility and awareness of the nutritional benefits of finger millet. Furthermore, millet-based product exports have also shown potential, as international markets seek diverse and nutritious foods to cater to health-conscious consumers. By adopting innovative packaging and ensuring quality standards, entrepreneurs can tap into the lucrative global market for finger millet-based products.

Conclusion

Finger millet is more than just a traditional grain; it is a powerhouse of nutrients and a versatile ingredient that lends itself to a wide variety of value-added products. From flour and snacks to beverages and baby foods, the growing range of finger millet-based products reflects a broader trend towards healthy, plant-based eating. As the demand for nutritious, sustainable foods continues to rise, finger millet offers a promising avenue for improving public health while supporting farmers and local economies. By embracing value-added products, we can ensure that this humble grain plays a vital role in addressing the nutritional needs of both current and future generations.

References

Harshitha, H., & Jayaram, D. (2019). Consumers preference for value-added products of finger millet (Eleusine coracana). *Indian Journal of Economics and Development*, *7*(9), 1-4.

Jindal, P., & Nikhanj, P. (2023). A review on processing technologies for value added millet products. *Journal of Food Process Engineering*, *46*(10), e14419.

Kaur, S., Kumari, A., Seem, K., Kaur, G., Kumar, D., Verma, S., ... & Riar, A. (2024). Finger millet (Eleusine coracana L.): from staple to superfood—a comprehensive review on nutritional, bioactive, industrial, and climate resilience potential. *Planta*, *260*(3), 75.

Sharma, D., and Yamer, P. (2022). Value addition of products from finger millet (Eleusine coracana). *Journal of Postharvest Technology*, *10*(2), 120-138.

Srivastava, S., & Arya, C. (2021). Millets: malnutrition and nutrition security. *Millets and Millet Technology*, 81-100.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

HIGH-YIELD MULBERRY VARIETIES FOR CLIMATE ADAPTATION: THE FUTURE OF RESILIENT SILK PRODUCTION

Article ID: AG-VO4-I12-31

***G. Swathiga and C.N. Hari Prasath**

Forest College and Research Institute, TNAU, Mettupalayam – 641 301, Tamil Nadu, India

*Corresponding Author Email ID: swathiga.g@gmail.com

Introduction

High-yield mulberry varieties are specially developed to produce a large quantity of nutritious leaves, which are essential to feed silkworms in silk production. These varieties have been breed or modified to adapt to various climates, resist diseases, and maximize yield. As climate change accelerates, the silk industry faces unique challenges. Extreme weather, unpredictable rainfall, and rising temperatures directly affect mulberry cultivation, which forms the foundation of sericulture. Traditional mulberry varieties may struggle to cope, making climate-resilient, high-yield varieties essential to ensure a steady supply of quality silk. In recent years, researchers have made significant advances in breeding and cultivating new mulberry varieties that are both high-yielding and climate-adaptive, promising a more sustainable future for silk producers worldwide.

The Need for Climate-Resilient Mulberry Varieties

Mulberry plants, primarily cultivated in tropical and subtropical regions, are particularly vulnerable to climate impacts like prolonged droughts, soil salinity, and extreme temperatures. These conditions reduce the productivity of mulberry leaves, the primary food source for silkworms, leading to lower silk yields. For instance, high temperatures can cause heat stress in mulberry plants, impairing leaf quality and even stunting growth. To counter these effects, scientists have been focusing on breeding mulberry varieties that thrive in various environmental stresses. These varieties not only help stabilize silk production but also support the livelihoods of millions of farmers dependent on sericulture, particularly in regions like India, China, and Thailand.

Breakthroughs in Mulberry Breeding

Modern breeding techniques, including marker-assisted selection and gene editing, have been instrumental in developing mulberry plants that are both high-yielding and climate-resilient. Here are a few of the most promising advancements:

1. Drought-Tolerant Mulberry Varieties

Some of the newly developed mulberry varieties have shown remarkable drought tolerance, allowing them to survive and even thrive in water-scarce conditions. By identifying and selecting drought-resistant traits, researchers have created mulberry plants with deeper root systems and improved water retention, which helps them cope with prolonged dry spells. Varieties like G4, S1635, and C1730 are examples that require less water while delivering optimal leaf quality, supporting silkworm health and productivity.

2. Salt-Resistant Varieties for Coastal and Saline Regions

Soil salinity is a significant challenge in many regions due to coastal expansion and rising sea levels. Salt-resistant mulberry varieties have been developed to overcome this challenge. By identifying genes that enable the plant to maintain productivity in high-salt environments, scientists are creating varieties that can survive and yield well in saline soils. This has opened new opportunities for silk production in previously unsuitable areas.

3. Heat-Resilient Mulberry Plants

Global temperatures are on the rise, with increasingly frequent heatwaves. Scientists are leveraging gene editing technologies like CRISPR to develop heat-resilient mulberry varieties that maintain leaf quality even under high temperatures. This ensures that silkworms receive consistent, high-nutrient feed, which is crucial for producing high-quality silk.

4. Rapid-Growth, High-Yield Varieties

In addition to climate adaptation, high-yielding mulberry varieties are being developed with faster growth cycles. This allows for more frequent harvests, translating to more silk production. The 'V1' and 'M5' varieties, for example, have become popular among silk producers due to their high leaf yield per hectare. These varieties are particularly beneficial for smallholder farmers who seek to maximize production on limited land.

Biotechnology: Transforming Mulberry Breeding

The integration of biotechnology in mulberry breeding has been a game-changer. Through advanced genetic techniques, researchers can identify genes linked to specific traits like drought tolerance or heat resistance. Marker-assisted selection (MAS) has significantly reduced the time required to develop new varieties by allowing scientists to focus on specific genes of interest.

CRISPR gene editing further enhances this process by enabling precise modifications at the genetic level. For example, scientists have experimented with genes that control the production of certain proteins, enhancing resilience without sacrificing leaf quality. These innovations in biotechnology are transforming mulberry breeding, making it faster, more efficient, and highly targeted.

Benefits Beyond Resilience

Developing high-yield, climate-adaptive mulberry varieties has a positive ripple effect on the entire sericulture industry. Here are a few additional benefits:

- **Increased Income for Farmers**: Higher-yielding mulberry varieties mean farmers can produce more silk per hectare, leading to higher profits, especially in areas where sericulture is a primary income source.
- **Reduced Resource Use**: Drought-resistant and salt-tolerant varieties require less water and can thrive in suboptimal soils, reducing the need for chemical inputs and intensive irrigation. This makes sericulture more sustainable and environmentally friendly.
- **Support for Smallholder Farmers**: Climate-resilient varieties can help smallholder farmers become more resilient to climate impacts, making their livelihoods more secure and reducing the risk of crop failures.

Future Directions: What's Next in Mulberry Research?

The sericulture sector continues to evolve, with scientists now exploring hybridization techniques that combine the strengths of different mulberry species. Crossbreeding traditional mulberry with wild, naturally resilient varieties can introduce desirable traits like pest resistance or improved leaf quality.

Another promising direction is *polyploidy breeding*, which involves increasing the number of chromosomes in the mulberry plant to enhance growth and resilience traits. This has shown promise in other crops and could be a breakthrough for mulberry breeding as well.

Furthermore, some researchers are investigating the use of AI and machine learning in mulberry cultivation. By collecting data on plant health, climate conditions, and soil quality, AI models can provide farmers with insights into optimal planting and harvesting times, thus boosting productivity.

Final Thoughts: A Path to Sustainable Silk Production

High-yield, climate-adaptive mulberry varieties are crucial for the future of sericulture in an increasingly unpredictable climate. Through the integration of biotechnology, traditional breeding, and cutting-edge research, the silk industry is transforming to become more resilient and sustainable. This innovation doesn't just benefit silk production; it also contributes to climate resilience in agriculture, strengthens rural economies, and provides a model for sustainable crop development.

Reference

Dutta, H., Bhattacharya, S., Sawarkar, A., Pradhan, A., Raman, R. B., Panigrahi, K. K., & Dutta, K. B. S. (2023). High yielding mulberry production through controlled pollination for enhanced vegetative growth and early sprouting suitable for tropical agroclimatic regions. The Pharma Innovation. 2023a, 12(3), 4485-4492.

Mogili, T., Sarkar, T., & Gnanesh, B. N. (2023). Mulberry breeding for higher leaf productivity. In The Mulberry Genome (pp. 57-114). Cham: Springer International Publishing.

Pavithra, M. R., Karur, A. S., Teja, K. S. S., Parmar, S., Sujatha, G. S., Kumar, G. A., ... & Jeevitha, P. (2024). Genetic Improvements in Silkworms: Enhancing Silk Yield and Quality. UTTAR PRADESH JOURNAL OF ZOOLOGY, 45(16), 164-172.

Volume: 04 Issue No: 12

PERIWINKLE - CANCER FIGHTING MIRACLE PLANT

Article ID: AG-V04-I12-32

Dr. A. Nithya Devi*, Dr. K. Indhumathi, Dr. S. Sheeba Joyce Roseleen, Dr.K.Kumanan, Dr. V.K.Sathya and Dr. M. Shanmuga Priya

Dr. M. S. Swaminathan Agrl. Coll. & Res. Inst., Eachangkottai, Thanjavur – 614 902

*Corresponding Author Email ID: nithyadevi.a@tnau.ac.in

Introduction

Periwinkle (*Catharanthus roseus* (L) G. Don), belonging to the family Apocynaceae, is one of the few medicinal plants which has found mention in the folks medicinal literature as early as 2nd BC. The plant has been widely used as an abortifacient, purgative, anti-diabetic, diuretic, hemorrhagic antimalarial, anti-dysentric and against skin diseases by the ancient people. Modern investigation have shown that periwinkle contains more than 100 alkaloids distributed through all the parts of the plant like ajmalicine, serpentine, reserpine and reserpinine which are well known for their hypotensive and antispasmodic properties. Periwinkle gained further importance after the isolation of vincrisine and vinblastine alkoloids which have importance in cancer, therapy. Vincristine sulphate is being marked under the trade name ONCOVIN, which is used against acute leukemia, and vinblastine sulphate as VELBE to cure Hodgkin's disease and other lymphomas. In addition to the above, the alkaloids leurosidine, leurosovine and rovidine also possess anticancer properties, but they are not used clinically.

Therapeutic uses

Plant is used in cancer and diabetes; root paste is used in septic wounds; root decoction is used in fever; leaves are used in menorrhagia; leaf juice is used in blood dysentery. The decoction of leaf is used for babies in gripping pain while the latex is useful in scabies. Plant contains hypotensive, sedative and antiviral activities.

Landscape use

Catharanthus roseus is also cultivated as an ornamental plant in gardens. Several cultivars have been bred to produce flowers in many shades of pink, red, lilac, and white, or in light shades with dark throats. Periwinkle is grown as a bedding or container plant for its bright flowers and glossy foliage.

Origin and Distribution

The plant is a native of Madagascar and from there it has spread to India, Indonesia, Indo-China, Philippines, South Africa, lsrael, USA and other parts of the world. In India, it is being grown in Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat and Assam in an area of about 3000 ha. Farmers prefer it because of its wide adaptability and its ability to grow on marginal lands and drought-tolerance that rules out crop failure. The presence of alkaloids all over the plant body confers immunity to cattle browsing and the crop loss due to pilferage.

USA is the world's largest user of this plant's raw material. A single firm which has the patent to manufacture Vinblastine and Vincristine sulphate have been consuming more than 100t of leaves of the plant annually. Most of it has been imported from Malagasy and the remaining from India and Mozambique. Hungary is also been one of the major consumer of its leaves followed by West Germany, Italy, Netherlands (raubasin), serpentine, etc. The total demand for these countries is more than 100 t of roots annually.

Botany

Catharanthus roseus is a perennial small herb or sub-shrub, up to 90 cm in height. Stem is erect, lax branching with flexible long branches, purple or light green. Leaves are simple, cauline, opposite, ex-stipulate, petiolate, elliptic ovate to oblong, 4-10 by 2-4 cm glabrous to pubescent, base acute or cuneate, apex obtusely apiculate and lateral nerves 10-12 pairs. Petiole is 1.0- 1.5 cm long. Inflorescence is recemose oraxillary or terminal cyme or solitary/paired and shortly pedicillate. Flower colour is pink/white and tubular, swollen in the region of anthers, throat of corolla-tube hairy. Androecium contains 5 stamens included in the corolla tube, filaments are very short, epipetalous, anthers forming a cone-like structure above the stigma. Gynoecium contains two carpels, which are free below, but united in the stylar region. Ovaries are two, free and single style with dumbbell stigma. After fertilization, the carpels separate and form two fruits which form a pair of elongated follicles. Seeds are small in size and black in colour, 1000 seeds may weight 1.2 gm.

Varieties

Nirmal and Dhawal are two varieties of periwinkle developed by CSIR-CIMAP in Lucknow, India.

Nirmal: A white-flowered variety

Dhawal: A mutant variety of Nirmal that produces more alkaloids and herbage

CIM-Sushil: New high vindoline yielding C. roseus variety developed through EMS-induced mutation breeding approach. It has dwarf character, spreading/bushy growth (wide canopy) and small dark green leaves. Its leaves have 0.2% vindoline content and ~5% total alkaloid content (% dry weight basis). Its estimated dry leaf yield potential is ~2418.3 kg/ha, estimated vindoline yield potential is ~4.8 kg/ha and estimated total alkaloid yield potential is ~120.9 kg/ha. It outperformed the check varieties, Nirmal and Dhawal, in content as well as yield of vindoline and total alkaloid. Its vindoline content is comparable to the global benchmark



Soil

The crop is quite hardy and grows well on a wide variety of soils, except those which are alkaline or water-logged. Deep sandy loam to loam soils of medium fertility are preferred for its large-scale cultivation. Because, in this soil there is not only a better development of roots, but it is also easy to take them out at harvest time.

Climate

The distribution of the plant shows that there is no specificity in its climatic requirements. It comes up well in tropical and subtropical areas. However, the growth in tropical areas is better than in the subtropical areas, where its growth is slow due to the low temperatures in winter. It can be successfully grown up to an elevation of 1300 m above sea level. A well distributed rainfall of 100 cm or more is ideal for raising this crop on a commercial scale under rainfed conditions.

Manures and Fertilizers

In areas where FYM is available, it is applied at the rate of 10-15 t/ha to obtain good growth and yield from periwinkle plants. If irrigation is available it is recommended to grow leguminous crops like sun hemp or horse gram and when then reach the flowering stage bury them inside the soil before sowing or transplanting periwinkle. Green manure will act as a substitute for FYM and is useful in the areas where it is either difficult to procure or it is very expensive. The seeds of the green manure crop should preferably be treated with bacterial inoculants prior to sowing, to increase the development of root nodules which absorb atmospheric nitrogen and fix it in the soil. In case organic manure is not applied, it is advisable to apply a basal dose of 25 kg N, 50 kg P_2O_5 and 75 kg K_2O per hectare per year.

Irrigation

In places where rainfall is distributed throughout the year, the plants do not require any irrigation. However, in areas where rainfall in restricted to a few months in a particular period approximately 4-5 irrigation will help the plants

Weed Control

This crop requires two weedings in the initial stages of its growth. The first weeding may be done about 60 days of sowing and the second at 120 days at again. Mulching the paid with cut grass or rice-straw will also minimize the weed growth.

Application of the chemical weedicide Sinhar at 4-5 kg/ha as a pre-emergent spray is highly effective against oil mount weeds similarly, the application of a mixture of 2-4-D and Gramaxone at the rate of 25 kg/ha to the soil before sowing keeps the weeds under control.

Insect Pests and Diseases

The plant is sufficiently hardy and practically free from the attack of insect pests and diseases. However, the oleander hawk month is reported on this crop. Occasionally, some plants have been found to suffer from the little leaf disease, due to infection be mycoplasma resulting in stunted growth and resetting of the leaves of the plant. The disease can be effectively checked by uprooting and destroying the affected plants.

Recently, another disease 'dieback' or twig blight or top rot caused by *Pythium butleri*, *Phytophthora nicotianae*, *P.debaryanum*, *Alternaria tenuissima* and *Colletotrichum demothum* has been found to affect the crop during the monsoon in some parts of the country. The disease can be controlled by spraying Dithane Z-78 at an interval of 10-15 days. The other fungal diseases reported on this crop are Fusarium wilt caused by *Fusarium solani* and blight caused by *Pythium aphanidermatum* as well as leaf-spot caused by *A. tenuissma, A. oltemata, Rhizoctonia solani.*

Harvesting

i) Roots

The crops are harvested after 12 months of sowing. The plants are cut about 7.5 cm above the ground level and dried for the stems leaves and seeds. The field is then copiously irrigated and when a reaches the proper condition for digging, it is ploughed and the root are collector. The roots are later washed well and dried in the shade.

ii) Leaves, Stem and Seeds

If there is a demand for leaves, two leaf stripping, the first after 6 months and the second after 9 months of sowing – can be taken. A third leaf stripping is also obtained when whole plant is harvested. After the plant is harvested it is dried in the shade. Its second nods dehisce and release the seeds with a light threshing which can be used for the next sowing.

The leaves and stems are also collected separately. It may be mentioned here; that the seeds collected in this way will have poor germination because they have been collected from pods in different degrades of maturity. Therefore, in order to obtain good seeds it is advisable to collect them from mature pods two to three months before the harvest of the crop. The aerial part of the plant between 7.5 cm and about 25 cm above the ground level is taken as the stem for the purpose of marketing. The total alkaloid content in the leaf varies from 0.15 to 1.34%, of which the average content of vinblastine is 0.002%, while that of vincristine is 0.005%.

Yield

Under irrigated conditions, about 4 t/ha of leaves, 1.5 t/ha of stem, and 1.5 t/ha of roots on an air-dried basis may be obtained. Whereas, under rainfed conditions, about 2 t/ha of leaves and 0.75 t/ha each of stem and roots on an air-dried basis may be obtained.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

Article ID: AG-VO4-I12-33

INFRARED DRYING OF FOODS

G.Amuthaselvi[1] and G.Anand[2]

[1]Assistant Professor (Food Process Engineering)

Department of Food Process Engineering, AECC&RI, TNAU, Coimbatore

[2]Associate Professor, TNAU, Coimbatore, Tamil Nadu, India

*Corresponding Author Email ID: g.amuthaselvi@gmail.com

Introduction

Exposing an object to infrared (IR) radiation (wavelength of 0.78 to 1000μm), the heat energy generated can be absorbed by food materials. The use of infrared radiation as a main or additional source of thermal energy for drying has been proposed and tested by numerous researchers. During the past decade infrared radiation has received more attention as a thermal energy source (or as an auxiliary energy source) for drying of many foods and agricultural materials. It has been found that drying time and energy consumption of a convective drying process are dramatically reduced when infrared radiation is applied. The dried product quality is also improved when compared to the case of hot air drying. For example, lower losses of vitamin C, volatile components and flavours; lower loss of carotene and better colour retention has been reported. Although infrared radiation can accelerate a drying process, foods and agricultural materials, which are heat-sensitive in nature, may be damaged or degraded if radiation intensity, which is the main factor influencing the product temperature, is not properly applied.

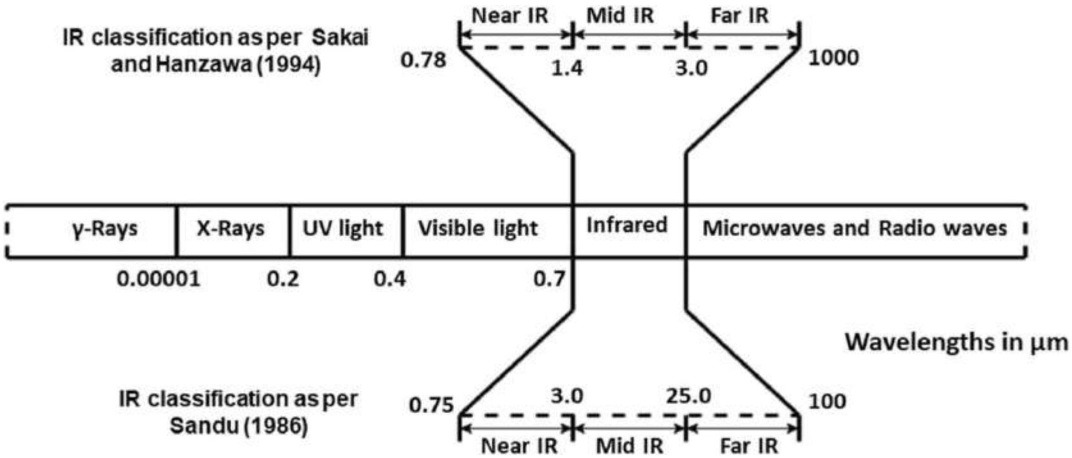
The agricultural, ceramic, chemical, food, pharmaceutical, pulp and paper, mineral, polymer, and textile sectors all use drying as one of their most frequent unit processes. Because it is challenging to completely comprehend the multiphase movement of heat, mass, and momentum in a solid wet substance, it is also one of the most complicated processes. Heat transfer to wet solids is highly particular to the needs of the product and can happen by convection, conduction, radiation, or occasionally a mixture of these factors .

Food dried by convective air uses more energy and takes a long time to dry during the decreasing rate period. Heat transport within food products during the decreasing rate period of convective heating is restricted due to their low thermal conductivity. Under comparable drying conditions, infrared (IR) heating, either by itself or in combination with other methods, has numerous advantages over convective air drying. Due to benefits including equipment compactness, quick transient reaction, substantial energy savings, and ease of integration with convective, conductive, and microwave heating, infrared drying is rapidly emerging as a significant source of heat treatment in the food sector.

IR heating is regarded as a viable technique for achieving the high quality of dried products like fruits, vegetables, and grains due to its performance. The literature describes several facets of industrial infrared drying systems based on food ingredients, irradiation intensity, radiator types and selection, and radiation characteristics . Infrared radiation is defined as electromagnetic radiation with a wavelength range of 0.78–1,000 m that exhibits both directional and spectral dependence. There are two common types of infrared heaters that are utilized in commercial settings: gas-fired heaters and electric heaters.

While gas-fired IR heaters create combustion on the burner surface by igniting premixed air and fuel stream, electric heaters emit radiation by sending an electric current through a resistance, which raises its temperature. Depending on the source's temperature, infrared radiation can be classified into three distinct categories: near-infrared (NIR), mid-infrared (MID), and far-infrared (FIR). Since energy from an emitter comes in a variety of wavelengths and the percentage of radiation in each band varies depending on a number of variables, including the emitter's temperature and emissivity, the spectrum dependency of infrared heating must be taken into account.

The body's total emissive power, which is determined by its surface properties and temperature, is the total quantity of radiation it emits per unit area per unit time. This energy has the ability to emanate at all wavelengths and in all directions. The absorption of incipient radiation is determined by the emissivity quality of food or nonfood materials exposed to infrared radiation. Moreover, the wavelength of the source and the surface material both affect a product's capacity to absorb this energy. The features of the product and the IR source's characteristics are crucial in choosing the assisted dryer and source wavelength.



Infrared Drying of Food Materials

The energy from every wavelength in the radiation spectrum is included in the overall emissive power. For any given source temperature, the radiation emitted is distributed over a broad range of wavelengths, with roughly one-third of the energy at wavelengths shorter than the peak energy wavelength (λmax) and two-thirds at wavelengths longer than the peak energy wavelength, as demonstrated graphically by the plotting of Planck's formula. As the heater's temperature rises, the peak wavelength shifts to a lower magnitude; hence, changing the source temperature modifies the heater's energy output.

It has been claimed that without heating the surrounding air, infrared radiation can be directly transmitted from the source to the sample surface.

The primary components of food, water and organic molecules, absorb a significant amount of infrared radiation, particularly at 3 and 6 m. MIR radiation at 3 m and FIR radiation at 6 m can be regarded as appropriate wavelengths to be fixed in large-scale IR dryers for food products that typically include 90% water since Fig. 1 illustrates the absorption of water at different wavelengths. Two characteristics of food products are especially crucial for radiative drying: (1) most food products exhibit a high spectral transmissivity for wavelengths smaller than roughly 2.5 m, and (2) the total transmissivity/ absorptivity varies with drying in relation to water content.

Both food and nonfood products can be heated using infrared technology. The drying of nonfood materials is often defined by distinct norms of final product than that of the food. Food drying is the most popular method for increasing food stability since it lowers the product's water activity, which lowers the likelihood of microbiological development while it is being stored. Therefore, the local temperature and moisture profiles affect the quality characteristics of food, whereas the surface temperature affects the quality of dried nonfood goods such dyes and colorants.

IR Drying and the Finished Product Quality

Due to its benefits, which include a short drying time, a final dried product of acceptable quality, and the capacity to save energy, infrared drying has grown in popularity recently for the drying of both food and nonfood materials. In contrast to microwaves, which enter a material deeper and cause volumetric heating, infrared radiation is typically absorbed by wet solid materials in their surface layer. The absorption properties of the material, which dictate the dryer's technical and financial viability, are intimately correlated with the energy efficiency of infrared dryers.

The literature contains a thorough assessment of the several studies that have used infrared radiation to examine the drying kinetics and quality features of various food products. Numerous investigations have concentrated on end qualities like color, texture, and loss of nutritional content in relation to the quality features of the finished products. infrared radiation affected the color deterioration of dried carrots and potatoes. For potatoes and carrots, the overall color alterations decreased by 37.6 and 18.1%, respectively. while long-term infrared heating treatments deepen the color of onions, they also observed that the pungency of heated onions decreased as the moisture level decreased.

It was discovered that IR irradiation killed the microbe on the surface of strawberries and carrots, making it possible to pasteurize viruses without lowering the quality of the food. The drying properties of apple slices under simultaneous IR dry-blanching and dehydration with intermittent heating. Using infrared radiation to dry noodles can both increase their quality and reduce cooking loss. fluidized bed drying in conjunction with NIR radiation to investigate the quality of soybean grains.

IR RADIATION HEATING IN DIFFERENT DRYERS

Despite its ability to reduce drying time, infrared heating is not appropriate for all drying systems due to its limited penetrating power, particularly during the falling rate period. Therefore, it may be determined that IR radiation in conjunction with other killing techniques is more effective and beneficial for achieving better outcomes. Carrots, bananas, apples, meat products, cashews, welsh onions, industrial tomato products, citrus press cake , barley , parboiled rice ,paddy , pomegranate arils ,vegetables , cabbage seeds , potato chips, and Murta berries.

Intermittent IR Drying

The intermittent method of drying with infrared heaters in convection dryers has been investigated by numerous researchers. Osmosed fruit items' IR drying in a heat pump dryer. It was discovered that intermittent infrared drying was effective for both osmosed and non-osmosed items. Additionally, it has been noted that during convective drying with intermittent infrared heating, osmotically treated potato and pineapple samples may have less color change than untreated ones. Additionally, by maintaining control over the sample's surface temperature, the scientists enhanced the intermittent infrared heating process by allowing the heater to shut off at a preset temperature. long ago that food products thicker than their depth of penetration to the infrared radiation were best suited for drying using intermittent irradiation techniques.

IR-Assisted Hot Air Drying

a qualitative economic assessment of an IR drier for the purpose of drying carrots and potatoes in a continuous IR-convective dryer. According to reports, the combined IR–convective dryer mode significantly cuts processing time (48%) and uses less energy (63%) for water evaporation than hot air drying. The results showed that the heat utilization efficiency for potatoes and carrots were 38.5 and 38.9%, respectively. the heat and mass transfer phenomena during the drying of longan fruit leather using a mix of convective and FIR drying. The ratio of the heat and mass transfer coefficients for the hot air method and a combination of hot air, two drying methods

It was discovered that the combined mode of operation displayed greater rates of mass and heat transmission. the energy and quality characteristics of paddy drying using a combination of hot air and infrared. The final quality of paddy was shown to be effectively improved by a combination of low-intensity infrared radiation (2000 W/m2), inlet air temperature (30C), and moderate input air velocity (0.15 m/s). Kelp is dried with infrared radiation. It was discovered that, in comparison to air drying, the overall drying time needed for IR drying products was roughly 120 minutes, or 56% less.

For wine grape pomace, there are three distinct drying methods: IR, convective, and sequential IR-convective. The highest drying rate was discovered to be IR drying, which shortened the drying time by more than It was discovered that the combined mode of operation displayed greater rates of mass and heat transmission. the energy and quality characteristics of paddy drying using a combination of hot air and infrared. The final quality of paddy was shown to be effectively improved by a combination of low-intensity infrared radiation (2000 W/m2), inlet air temperature (30C), and moderate input air velocity (0.15 m/s). Kelp is dried with infrared radiation. It was discovered that, in comparison to air drying, the overall drying time needed for IR drying products was roughly 120 minutes, or 56% less. For wine grape pomace, there are three distinct drying methods: IR, convective, and sequential IR-convective. The highest drying rate was discovered to be IR drying, which shortened the drying time by more than 47.3% compared with other methods.

IR-Aided Vibration Drying Method

IR drying has limited use for grain drying, despite its great appeal for food drying. The explanation for this is The surface layer may heat up more quickly than the layers underneath if the grain bed depth increases. Vibrated mode-IR drying can get rid of these restrictions. Das et al. (2004) investigated the drying properties of high moisture paddy under various vibrating settings for varying grain bed depths and irradiation intensity levels, and they demonstrated that infrared radiation is also highly advantageous in this category.

IR (Vacuum Drying)

By using a vacuum to dry heat-sensitive food items, vaporization can be encouraged even at low temperatures. In the laborious vacuum-drying process, IR heaters can be used to successfully speed up food drying. the use of ceramic-coated radiators for IR-vacuum drying of Welsh onions. It has been discovered that IR can alter a food sample's quality characteristics and have a major impact on its chlorophyll concentration.

IR-Assisted Microwave Drying

When absorbed, any electromagnetic radiation has the potential to heat the substance. The moist food ingredients strongly absorb both microwave and infrared radiation. A well-known issue with microwave cooking is moisture buildup at the meal's surface, which causes the dish to become soggy rather than crisp. This phenomenon occurs as a result of the surrounding air's incapacity to eliminate the moisture at the rate at which it is rising to the surface from the inside. Therefore, adding an external infrared source can improve the elimination of surface moisture.

The drawbacks of infrared drying include surface browning and burning due to overheati ng.Cake making can benefit somewhat from the use of certain food items. Additionally, roasting hazelnuts was another instance of using infrared in a microwave oven.

Freeze Drying Assisted by Infrared in the dehydration process known as "freeze drying," ice is sublimated from a frozen product using suction. The majority of degradation and microbiological reactions are suppressed due to the low operating temperature and lack of liquid water. Reducing processing time can potentially lower the cost of the costly process of freeze-drying. A new method called freeze drying with FIR heating can lower the chance of ice melting since the heating plate comes into close touch with the sample tray.

IR-assisted sweet potato freeze drying, and an empirical model was created. When compared to traditional freeze drying, it was discovered that IR-assisted freeze drying shortened the drying time. Additionally, employing surface response methods, the authors investigated the drying of yam slices—a functional food and herbal medicinal ingredient—in freeze dryers aided by FIR heaters (Lin et al. 2007). It was discovered that using FIR radiation to freeze-dry yam slices decreased both the drying time and overall color difference.

The flavonoid composition and antioxidant properties of dried samples and citrus press cakes (CPC) after IR drying were assessed. The FIR-dried sample had a little reduced extraction yield but about the same total flavonoid concentration and antioxidant activity as the freeze-dried CPC sample. As a result, FIR drying can be used to replace freeze drying of PCC samples and emerge as a technique that benefits the economy.

Conclusion

The biggest benefit of IR heating is that it can be added to a variety of direct and indirect dryers to serve as an extra heating source, cutting down on drying time and energy usage. One innovative way to achieve the required product quality is by using infrared radiation in microwave ovens and freeze dryers. Understanding the heat and mass transport in IR-freeze drying and IR-microwave drying is still necessary, despite the fact that several researchers have created a satisfactory model for the IR-convective drying process.

References

Abukhalifeh, h., Dhib, R. and Fayed, m.e. 2005. Model predictive control of an infrared-convective dryer. Dry. Technol. 23, 497–511. Afzal, t.m. And abe, T. 1998. Diffusion in potato during far infrared radiation drying. J. Food Eng. 37, 353–365.

Basman, A. and Yalcin, S. 2011. Quick-boiling noodle production by using infrared drying. J. Food Eng. 106, 245–252.

Bualuang, O., Tirawanichakul, Y. and Tirawanichakul, S. 2013. Comparative study between hot air and infrared drying of parboiled rice: Kinetics and qualities aspects. J. Food Process. Preserv. 37, 1119–1132. Caglar, A., Togrul, I.T. and Togrul, H. 2009. Moisture and thermal diffusivity of seedless grape under infrared drying. Food Bioprod. Process. 87, 292–300

Lewicki, P.P., Witrowa-Rajchert, D. and Nowak, D. 1998. Effect of drying mode on drying kinetics of onion. Dry. Technol. 16, 59–81.

Likitrattanaporn, C. and Noomhorm, A. 2011. Effects of simultaneous parboiling and drying by infrared radiation heating on parboiled rice quality. Dry. Technol. 29, 1066–1075.

Sharma, G.P., Verma, R.C. and Pathare, P.B. 2005. Thin-layer infrared radiation drying of onion slices. J. Food Eng. 67, 361–366

Salehi F, Kashaninejad M (2018) Modeling of moisture loss ki-netics and color changes in the surface of lemon slice during the combined infrared-vacuum drying. Inf Process Agric 5:516–523

Younis, M., D. Abdelkarim, and A. Zein El-Abdein. 2017. Kinetics and mathematical modeling of infrared thin-layer drying of garlic slices. Saudi J. Biol. Sci.. 25(2), 332-338.

Zhu, A., and X. Shen. 2014. The model and mass transfer characteristics of convection drying of peach slices. Int. J. Heat Mass Transfer. 72:345–351. doi: 10.1016/j.ijheatmasstransfer. 2014.01.001.

Zhu, Y., and Z. Pan. 2009. Processing and quality characteristics of apple slices under simultaneous infrared dry-blanching and dehydration with continuous heating. J Food Eng. 90:441–452. doi: 10.1016/j.jfoodeng.2008.07.015.

Volume: 04 Issue No: 12

STATUS OF PULSES PRODUCTION IN INDIA AND THEIR INSECT BIOTIC CONSTRAINTS

Article ID: AG-V04-I12-34

***P Thilagam[1] and S Srividhya[2]**

[1] Agricultural Research Station, TNAU, Virinjipuram, Tamil Nadu, India

[2] Horticultural College and Research Institute, TNAU, Paiyur, Tamil Nadu, India

*Corresponding Author Email ID: thilagamp@tnau.ac.in

Introduction

Globally, India is the largest producer (25%), consumer (27%) and importer (14%) of pulses. Around 20% of the area is planted with food grains, and pulses produce 7-10% of all the food grains produced in the nation (Mohanty and Satyasai, 2015). Due to un favourable weather circumstances, the total amount of pulses produced in 2013-2014, which was 19.78 million tonnes, was decreased to 17.20 million tonnes.

Majority of Indians are vegetarians, pulses play an important role in their diet as a protein alternative (22-24%). Pulses and cereals together make an ideal vegetarian diet with high biological value since they add proteins, vital amino acids, vitamins, and minerals to the diet's basic cereals. Pulses have a significant role in nourishing the soil through biological nitrogen fixation and can be grown in a variety of soil types and climates. Additionally, pulses are used in intercropping, mixed cropping, and crop rotation, all of which contribute to the sustainability of farming systems. Chickpea and pigeonpea are the two most important pulse crops farmed in India, taking up collectively 53% of the total land used for growing pulses and producing more than 63% of it.

From the seedling stage to maturity and storage, pulses are extremely vulnerable to harm from insect pests. Pod borers and termites are the principal pests that harm pigeonpea and chickpea plants. The pigeonpea crop, which is typically planted at the start of the monsoon and matures between November and March, is damaged by insect pests throughout both the rainy and post-rainy (rabi) seasons. More than 300 different insect and mite species have been found to infest pulses in India, including pigeonpea, chickpea, 45 different types of mungbean, and urdbean. Some of the important species are rare, while others are common. The losses brought on by pests differ from one agro-climatic zones to another and even within a zone between local regions. Estimates of crop losses are frequently inaccurate and result in false impression. The report is frequently based on the percentage of pod damage in crops including peas, pigeonpea, greengram, and blackgram. Therefore, even if just one grain in a pod is determined to be damaged, the entire pod is still considered damaged even if part of the grains is still safe to eat. Therefore, rather than on a pod basis, the damage should be calculated. Pigeonpea pod borer complex has regularly been blamed for 30–50% crop losses in both early and late-maturing cultivars. The losses in chickpea, greengram and blackgram are projected to be between 7 and 15% and 20% annually, respectively.

Due to changes in cropping practices, insecticide treatment patterns and the introduction of high-yielding varieties, the insect pest complex of pulses has undergone a significant transformation during the past 20 years. The principal insect pests, which have become increasingly difficult to control due to their development of pesticide resistance, resurgence, and secondary outbreak due to the indiscriminate use of insecticides, pose a serious danger to the production of pulse crops. Therefore, thorough knowledge of the insect pest complex, their status and temporal correlation with crop, losses, and type of damage is of utmost relevance in order to develop pest control solutions that are economically viable, ecologically sound, and socially acceptable

Table 1: Major insect pests that contribute for yield loss in chickpea

Scientific name	**Common name**	**Order**	**Family**
Helicoverpa armigera (Hubner)	Gram pod borer	Lepidoptera	Noctuidae
Autographa nigrisigna (Walker)	Semilooper	Lepidoptera	Noctuidae
Agrotis ipsilon (Hufnagel)	Cutworm	Lepidoptera	Noctuidae
Odontotermes obesus (Rambur)	Termite	Isoptera	Termitidae

Table 2: Major insect pests that contribute for yield loss in Pigeonpea

Scientific name	Common name	Order	Family
Helicoverpa armigera (Hubner)	Gram pod borer	Lepidoptera	Noctuidae
Melanagromyza obtusa (Malloch)	Pod fly	Diptera	Agromyzidae
Maruca vitrata (Geyer)	Spotted pod borer	Lepidoptera	Pyralidae
Exelastis atomosa (Wals.)	Plume moth	Lepidoptera	Pterophoridae
Etiella zinckenella (Treit.)	Spiny pod borer	Lepidoptera	Pyralidae
Lampides boeticus (Linn.)	Blue butterfly	Lepidoptera	Lycaenidae
Clavigralla gibbosa (Spinola)	Pod bug	Hemiptera	Coreidae
Apion clavipes (G.)	Pod weevil	Coleoptera	Curculionidae
Mylabris pustulata (Thurnberg)	Blister beetle	Coleoptera	Meloidae
Callosobruchus spp. (L.)	Bruchids	Coleoptera	Bruchidae

Table 3: Major insect pests that contribute for yield loss in Green gram and Black gram

Scientific name	Common name	Order	Family
Bemisia tabaci (Gennadius)	Whitefly	Hemiptera	Aleyrodidae
Ophiomyia phaseoli (Tryon)	Stem fly	Agromyzidae	Diptera
Madurasia obscurella (Jacoby)	Galerucid beetle	Coleoptera	Chrysomelidae
Spilosoma obliqua (Walker)	Bihar hairy caterpillar	Lepidoptera	Arctiidae
Amsacta moorei	Red hairy	Lepidoptera	Arctiidae

(Butler)	caterpillar		
Spodoptera litura (Fab.)	Tobacco caterpillar	Lepidoptera	Noctuidae
Maruca vitrata (Geyer)	Spotted podborer	Lepidoptera	Pyralidae
Megalurothrips distalis (Karny)	Bean thrips	Thysanoptera	Thripidae
Clavigralla gibbosa (Spinola)	Pod bug	Hemiptera	Coreidae

For effective management of insect pests in different pulses ecosystem the following integrated pest management (IPM) practices has to be followed.

IPM in chick pea

All available management techniques are used in a complementary way in integrated pest management (IPM). All farmers must simultaneously plant less vulnerable cultivars at the best time for *H. armigera* management and they should use relatively safer insecticides based on economic threshold levels (ETL).

Before Sowing

- Deep summer ploughing

At Sowing

- Timely sowing
- Selection of resistant/tolerant varieties
- Use of trap crops marigold/intercropping with coriander/mustard

Standing Crop

- Regular field scouting
- Installation of pheromone trap at 20–25/ha
- Installation of bird perches at 35–40/ha
- At ETL (one larva/m row) or three to four moths trapped per night in four to five successive nights, first spray of NSKE (5%), second spay of *Ha*NPV at 250 LE (larval equivalent), third need-based spray of relatively ecofriendly insecticide, i.e., spinosad 0.02% (0.4 ml/l water).

	
Spotted pod borer	**Gram pod borer**
	
Whitefly	**Podfly**
	
Blister beetle	**Blue butterfly**
	
Pod bug	**Plume moth**

Major Insect pests of Pulse crops (Chick pea, Pigeonpea, Greengram and Blackgram)

IPM in Pigeonpea

Before Sowing:

- Deep summer ploughing
- Application of neem seed powder at 50 kg/ha or neem cake at 500 kg/ha in nematode-infested soils

At Sowing:

- ✓ Timely sowing and sowing on ridges
- ✓ Selection of disease-resistant/disease-tolerant varieties
- ✓ Seed treatment with carbendazim + thiram (at 1 + 2 g/kg) or Trichoderma and carboxin(10 g + 1 g/kg)
- ✓ Seed treatment with imidacloprid 70WS at 3 g/kg
- ✓ Seed treatment with carbosulfan at 3 g/kg seed in nematode-infested soils
- ✓ Intercropping with sorghum, sesamum, finger millet, etc.

Standing Crop

- ✓ Intensive monitoring of crop
- ✓ Spraying of metalaxyl at 1 gm/l water or mancozeb 2.5 gm/l water, if phytophthorablight appears
- ✓ Installation of pheromone trap at 20–25/ha and bird perches at 35–40/ha
- ✓ Removal of diseased plants
- ✓ Handpicking and jarring of insects
- ✓ Spraying of NSKE (5%), HaNPV 350LE or neem-based formulations
- ✓ Spraying of insecticides like dimethoate 30 EC (0.03%) or spinosad 45 SC (0.02%), indoxacarb 14.5 SC at 60 g a.i./ha or emamectin benzoate 5WSG at 11 g a.i./ha

IPM in Green gram and Black gram

Before Sowing:

- ✓ Soil application: Phorate/carbofuran at 1 kg a.i./ha
- ✓ Seed treatment:
- ✓ Imidacloprid 70 WS at 3 g/kg seed
- ✓ Imidacloprid 17.8 SL at 3 ml/kg seed
- ✓ Dimethoate 30 EC at 5 ml/kg seed

After Sowing:

- ✓ Foliar spray: 30–35 days after sowing for the control of thrips
- ✓ Dimethoate 30 EC at 2.0 ml/lit
- ✓ Imidacloprid 17.8 SL at 0.2–0.4 ml/lit
- ✓ Triazofos 40 EC at 1.5 ml/lit

In Standing Crop:

- ✓ Removal and destruction of MYMV-infested plants
- ✓ Collection and destruction of egg masses and skeletonized leaves along with early instarlarvae of hairy caterpillar and *Spodoptera litura*
- ✓ Deploying of light traps or bonfire against hairy caterpillar moth
- ✓ Need-based spray of any of the following insecticides: Quinalphos 25EC at 2.0 ml/litChlorpyrifos 20 EC at 2.5 ml/lit (blister beetle) Phosalone 35EC at 2.5 ml/lit

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

COLLABORATIVE STRATEGIES FOR CLIMATE ACTION: THE ROLE OF PUBLIC-PRIVATE PARTNERSHIPS

Article ID: AG-VO4-I12-35

Dr. S.R.Padma*

Assistant professor (Agricultural Extension)

Tamil Nadu Agricultural University, Coimbatore-3, Tamil Nadu, India

Corresponding Author Email ID**:** padmasr@tnau.ac.in

Abstract

Public-Private Partnerships (PPPs) play a pivotal role in addressing climate change by leveraging the strengths of both sectors. Governments provide regulatory frameworks, funding, and policy direction, while private entities contribute innovation, technology, and efficiency. Together, they mobilize resources and expertise to implement sustainable solutions such as renewable energy projects, green infrastructure, and carbon reduction initiatives. PPPs enhance scalability and long-term impact by fostering shared risks and benefits. They are critical for financing and deploying large-scale climate initiatives, particularly in developing regions where resources are limited. Collaboration between public institutions and private enterprises ensures the integration of economic, social, and environmental goals, making PPPs a cornerstone for achieving global climate resilience and sustainability.

Key Words: Public-Private Partnerships, Climate action, key areas, benefits, challenges

Introduction

Public-Private Partnerships bring together governments, private enterprises, and sometimes non-governmental organizations (NGOs) to design, fund, and implement projects that contribute to climate change mitigation and adaptation. The public sector provides policy frameworks, regulatory support, and often initial funding. The private sector contributes technical expertise, efficiency, and additional financial resources. Together, these partners can address systemic challenges such as reducing carbon emissions, transitioning to renewable energy, and building climate-resilient infrastructure.

Key Areas of Climate Action through PPPs

PPPs are instrumental in accelerating the transition to clean energy. Governments collaborate with private companies to build solar farms, wind energy projects, and hydropower plants. Climate-smart cities rely on PPPs to create efficient public transportation, green buildings, and waste management systems. Infrastructure projects, such as flood defences, drought-resistant irrigation systems, and disaster-resilient housing, often depend on PPPs for design and funding. Governments' partner with private enterprises to restore forests, wetlands, and other ecosystems that serve as natural carbon sinks. PPPs foster the development and deployment of innovative technologies such as carbon capture and storage (CCS) and smart grid systems.

Benefits of PPPs in Climate Action

By combining public funds with private investments, PPPs amplify the financial resources available for climate projects. This reduces the financial burden on governments, especially in developing countries. The private sector brings expertise in project management and technology development, ensuring projects are cost-effective and cutting-edge.PPPs distribute financial, operational, and environmental risks between the public and private sectors, making ambitious projects feasible. Successful PPP models can be replicated and scaled up, broadening their impact on climate action globally.

Challenges and Criticisms of PPPs

Despite their potential, PPPs in climate action face several challenges. Misaligned goals between governments and private entities can hinder project implementation. Clear policy frameworks are essential for effective collaboration. While PPPs mobilize resources, some projects require substantial upfront investment, which may deter private sector participation. Ensuring that private partners meet environmental and social standards is critical. A lack of transparency can lead to public distrust. PPPs may prioritize profitable regions or projects, leaving vulnerable communities underserved.

Policy Recommendations for Strengthening PPPs

- Governments should create policies that incentivize private participation while safeguarding public interests.
- Training programs for public officials and private sector actors can improve the design and execution of PPP projects.

- Establish robust mechanisms to track progress, ensure accountability, and measure the impact of climate projects.
- Ensure PPP projects address the needs of marginalized and vulnerable communities.
- Leverage tools like green bonds and blended finance to attract private investment.

Conclusion

Public-Private Partnerships hold immense potential to accelerate climate action by combining the resources, expertise, and capabilities of governments and private enterprises. While challenges remain, strategic planning, transparent operations, and equitable implementation can maximize the benefits of PPPs. As the world faces escalating climate risks, PPPs represent a powerful mechanism to mobilize resources, foster innovation, and create sustainable solutions for a resilient future.

References

Hodge, G. A., Greve, C., & Boardman, A. E. (2010). *International Handbook on Public-Private Partnerships.* Edward Elgar Publishing.

World Bank Group (2020). *Public-Private Partnerships: Reference Guide.*Available at: World Bank PPP Reference Guide

Koppenjan, J. F. M., & Enserink, B. (2009). "Public-Private Partnerships in Urban Infrastructures: Reconciling Private Sector Participation and Sustainability." *Public Administration Review*, 69(2), 284-296.

UNFCCC (2015). *Paris Agreement.* Available at UNFCCC Website

OECD (2018). *Blended Finance and PPPs for Climate Action.* Organisation for Economic Co-operation and Development.

Volume: 04 Issue No: 12

BOOSTING MUNG BEAN PRODUCTIVITY THROUGH KVK TECHNOLOGIES IN NAGAUR DISTRICT

Article ID: AG-VO4-I12-36

H.R. Choudhary[1*], Gopichand Singh[2], Bhawana Sharma[3], Budharam[4] and Kalpana Choudhary[5]

[1]Subject Matter Specialist (Agronomy), [2]Senior Scientist & Head,
[3]Subject Matter Specialist (Home science), [4]Subject Matter Specialist (Animal husbandry) and [5]Subject Matter Specialist (Horticulture),
Krishi Vigyan Kendra, Athiyasan, Nagaur-I, Agriculture University, Jodhpur, Rajasthan, India
*Corresponding Author Email ID: drhariramchoudhary@gmail.com

Introduction

The farmer used to get annual income of Rs. 8,10,000/- from Kharif and Rabi crops, before 2020. He was facing problems like lack of awareness, marketing and low crop production etc.

Name of farmer: Devi Lal S/o Baksha Ram
Address: Village-Lanch ki Dhani, Saugawas,
Tehsil: Merta city, Dist.- Nagaur, Rajasthan
Age: 62 years
Education: 3rd Class
Size of land holding (in ha): 25 ha

Intervention of KVK:

Shri Devi Lal participated in KVK trainings to learn about the technologies of seed production of Mung bean for higher productivity. Krishi Vigyan Kendra, Nagaur-I conducted seed production programme on Mung bean (Variety IPM 2-14) under Seed hub project during Kharif-2020 his field. Shri Devi Lal took Mung bean seed production programme in his 20 ha land under seed hub project in farmer participatory mode with KVK. Total Mung bean seed production was 345 quintals during Kharif-2024.

Outcome:

He is getting triple income as compared to earlier. He is getting average annual income of Rs. 24,40,000/- in addition to cost saving through adoption of improved cultivation of crops.

Images:

नागौर पत्रिका 08 राजस्थान पत्रिका

केवीके ने तैयार किया मूंग का उन्नत बीज

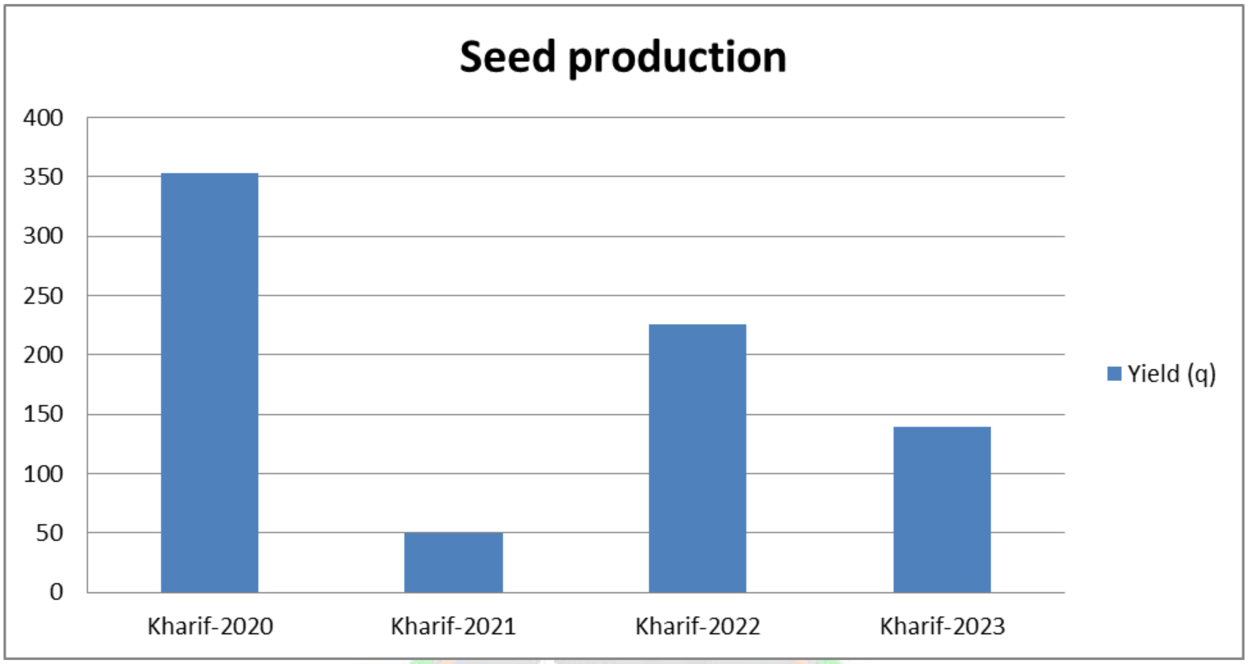
अधिक उत्पादन का दावा

सोमवार से किसानों के लिए कृषि विज्ञान केंद्र अठियासन पर रहेगा उपलब्ध

पत्रिका न्यूज़ नेटवर्क

Salient Achievements of Seed Hub (2020-2023)

S.N.	Crop	Year	Variety	Yield (q)	Income (Rs.)
1.	Mung bean	*Kharif*-2020	IPM-2-14	352.90	49,40,600
2.		*Kharif*-2021	MH-421	50.00	7,50,000
3.		*Kharif*-2022	MH-1142	225.36	33,80,400
4.		*Kharif*-2023	GM-7	139.88	20,98,200
Total				**768.14**	**1,11,69,200**



Impact of quality pulses seed produced and supplied to farmers:

(1) Crop failure risk minimization due to resistance/tolerance of improved varieties against biotic & abiotic stresses.

(2) Decrease in yield gap.

(3) Upliftment in socio-economic status of farmers & farm families.

(4) Quality seed availability builds faith & creates rapport of the KVK in the area.

Conclusion

Establishment of such seed hub centre may play a major role in production of quality seed at local level which helps in timely supply of seed to the farmers. Required seed replacement rate (SRR) especially in pulses for recently released improved varieties can be meet out only by production of sufficient quantity of quality seed at local level & KVK can play a major role in this. To achieve the target of doubling farmer's income, quality seed availability of pulses at local level at right time may play a vital role.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

JAUHAH: A TRADITIONAL FERMENTED STICKY RICE OF THE RONGMEI NAGA TRIBE OF MANIPUR

Article ID: AG-VO4-I12-37

***Dr Angam Raleng[1] and Robita Riamei[2]**

[1,*]Assistant Professor, College of Agricultural Engineering and Post Harvest Technology, (CAU, Imphal), Ranipool, Sikkim – 737135

[2]Assistant Professor, Department of Home Science, GP Women's College, D.M. University, Imphal, Manipur – 795001, India

*Corresponding Author Email ID: angamraleng@gmail.com

Introduction

The Rongmei Naga tribe is one of the indigenous tribes of Manipur, Assam, and Nagaland. The Rongmei people have a rich cultural heritage, deeply tied to the land and its natural resources. They have long relied on traditional agriculture, cultivating crops such as sticky rice and using local fermentation techniques to create food and beverages. Fermentation has been a key method for preserving food and enhancing its flavors, especially in the cooler climates of the hills, where storage and preservation are essential.

Jauhah: The fermented sticky rice

Jauhah, a fermented rice dish, holds a special place in the culinary practices of the Rongmei people particularly in Noney and Tamenglong districts of Manipur. It is used in social gatherings, festivals, and religious ceremonies. The fermented rice has nutritional benefits, being rich in probiotics and digestive enzymes, enhancing the community's overall health and well-being. Jauhah is deeply embedded in the culture of the Rongmei Naga tribe of Manipur. Traditionally prepared during important occasions such as festivals, religious ceremonies, and social gatherings, Jauhah symbolizes unity and community sharing. The fermented rice dish is served to honor guests, indicating its role in promoting social bonds. It is often used in ritualistic practices, where rice, being a sacred grain, holds spiritual significance. In this sense, Jauhah goes beyond being a mere food item, contributing to the preservation of cultural heritage.

Nutritional and Health Benefits

1. **Probiotic Richness:** Fermentation naturally increases the probiotic content of the rice. The live beneficial bacteria, such as *lactobacillus*, that thrive during fermentation enhance gut health, improving digestion and nutrient absorption. This makes Jauhah particularly valuable in supporting a healthy digestive system for the community.
2. **Digestive Enzymes:** The fermentation process also leads to the development of digestive enzymes that break down complex carbohydrates, making the rice easier to digest. This helps in alleviating common digestive issues and supports the overall well-being of individuals.
3. **Enhanced Nutrient Availability:** Fermented rice, like Jauhah, has enhanced bioavailability of nutrients like B vitamins, iron, and magnesium. Fermentation reduces antinutrients such as phytic acid, making these essential nutrients more accessible to the body.

Preparation Process

1. **Ingredients & Equipment:**
    - **Sticky Rice (Glutinous Rice):** This is the main ingredient. Sticky rice has a higher starch content, which makes it ideal for fermentation.
    - **Khai (Traditional Yeast):** A fermentation starter made from rice flour, herbs, and wild plants that promote microbial growth.
    - **Roselle Stem Fiber:** Used for sealing the fermentation container.
    - **Earthen Pot (or similar traditional vessel):** Ideal for the fermentation process due to its porous nature, which allows for slow exchange of air and moisture.
2. **Step 1: Washing and Cooking Sticky Rice**
    - Begin by thoroughly washing the sticky rice multiple times to remove any dust or impurities. The washing also helps soften the rice grains.
    - Cook the rice with just enough water so that it becomes soft but not mushy. Sticky rice requires less water than regular rice due to its higher starch content.
3. **Step 2: Cooling the Cooked Rice**
    - Once the rice is cooked, spread it out in a thin layer on a bamboo basket or a clean surface to cool it down. Cooling is essential because it ensures that the yeast added later is not killed by heat.

4. **Step 3: Mixing with Khai (Traditional Yeast)**
    - After the rice cools to room temperature, sprinkle the Khai, the traditional yeast, over the rice.
    - The yeast is gently mixed into the rice by hand to ensure even distribution. The Khai contains the necessary microorganisms, primarily yeast and bacteria, to initiate the fermentation.
5. **Step 4: Fermentation Setup**
    - Once the rice and yeast are mixed, transfer the mixture into an earthen pot.
    - After placing the rice in the pot, the top is sealed with Roselle stem fibers. The fibers create an airtight seal, which is important for controlling the fermentation process. The pot is traditionally kept near the household's fire hearth, where the warmth aids in the fermentation.
6. **Step 5: Fermentation Period**
    - The rice mixture is left to ferment for about 3 to 5 days. The fermentation period can vary based on the ambient temperature. Warmer conditions, such as near a fire hearth, encourage faster fermentation.
    - During fermentation, the rice develops a complex flavor profile, breaking down the starches into sugars and alcohol. Both liquid and solid by-products are formed, with a slightly sour and sweet taste.
7. **Step 6: Ready to Serve**
    - After 5 days, Jauhah is ready to be consumed. Both the liquid and solid parts are edible.
    - The liquid part is often drunk, and the solid fermented rice can be eaten as is or mixed with other ingredients. Its tangy, sweet flavor makes it a favourite during traditional feasts and ceremonies.

Social and cultural significance of Jauhah

The social and cultural significance of Jauhah, a traditional fermented sticky rice dish, lies deeply embedded in the heritage and communal practices of the Rongmei tribe of Manipur. This dish plays a vital role in shaping and reflecting the tribe's identity, offering much more than just sustenance. Below is a detailed explanation of its social and cultural importance:

1. A Symbol of Tradition and Heritage

Jauhah, like many indigenous foods, is passed down from generation to generation. The preparation method, ingredients, and serving traditions are all part of the tribe's long-standing cultural heritage. By preserving and continuing the practice of making Jauhah, the Rongmei tribe ensures the preservation of their cultural identity in the face of modernization. It represents a connection to the ancestors and their way of life.

2. Ritualistic and Ceremonial Role

Jauhah is an integral part of various ceremonies, festivals, and rituals among the Rongmei tribe. It is often prepared during special events such as weddings, harvest celebrations, and religious ceremonies. In these contexts, the dish is not just food but a ceremonial offering or a communal meal that marks important life events. The preparation and sharing of Jauhah reinforce the communal spirit and emphasize the values of sharing and togetherness.

3. Fostering Social Bonds

Food, in many cultures, acts as a medium for bringing people together, and Jauhah is no different. Its preparation is often a collective effort, with community members—especially women—gathering to prepare the rice, ferment it, and share the meal. This process strengthens social ties, creating a space for people to bond over shared work and common tradition. The communal aspect of preparing Jauhah reflects the tribe's deep-rooted emphasis on cooperation and collective responsibility.

4. Reflection of Environmental Harmony

The ingredients used in Jauhah, particularly the sticky rice and the natural fermentation process, are deeply connected to the environment and agricultural practices of the Rongmei tribe. The dish showcases the tribe's knowledge of local resources and their harmony with nature. The use of sticky rice, a crop that thrives in the region, symbolizes the tribe's connection to their land and their sustainable agricultural practices.

5. Preservation of Culinary Knowledge

Jauhah is part of a broader effort to preserve the culinary knowledge of the Rongmei tribe. Traditional food practices are not just about taste or nutrition but carry the knowledge of sustainable food practices, fermentation techniques, and the use of indigenous ingredients. By maintaining the tradition of making Jauhah, the tribe preserves this specialized knowledge that might otherwise be lost.

6. Embodiment of Identity

For the Rongmei people, Jauhah is more than just a dish; it is an embodiment of their identity. The uniqueness of this food reflects the tribe's distinct cultural practices, values, and their place in the larger fabric of Northeast India. In modern times, when indigenous communities are working to maintain their distinct identities in the face of rapid globalization, Jauhah becomes a symbol of cultural pride and resilience.

7. Passing Down Knowledge

The preparation of Jauhah is an opportunity for older generations to pass on their knowledge and skills to younger members of the tribe. It’s a moment of cultural education, where the younger generation learns not only how to make the dish but also its significance and history. This intergenerational transfer of knowledge strengthens cultural continuity and ensures that the traditional practices of the Rongmei people are not lost.

Future Developments:

1. **Research and Documentation:** More comprehensive studies on Jauhah’s microbial profile could lead to a better understanding of its probiotic potential. Scientific documentation of its preparation methods and health benefits will help preserve this culinary practice and provide insights into indigenous fermentation techniques.
2. **Health and Commercial Potential:** With growing global interest in fermented foods for their health benefits, Jauhah could be promoted as a functional food rich in probiotics. Its commercial production, with proper hygiene and controlled fermentation, could cater to health-conscious consumers looking for natural, probiotic-rich foods.
3. **Standardization and Innovation:** There is potential for standardizing the fermentation process, including the use of selected fermentation starters to ensure consistent quality, taste, and probiotic content. This could make Jauhah more accessible to modern consumers while preserving its traditional essence.
4. **Integration in Modern Cuisine:** Jauhah could be creatively integrated into contemporary dishes, appealing to wider audiences without losing its cultural significance. This fusion of traditional and modern culinary practices could keep the dish relevant in evolving food trends.
5. **Preservation of Cultural Heritage:** As globalization accelerates, there is a pressing need to preserve indigenous food practices like Jauhah. Efforts to promote its cultural and

nutritional importance through educational programs, festivals, and social media campaigns can ensure that the younger generation appreciates and continues these traditions.

By merging traditional knowledge with modern food science, Jauhah can not only survive but thrive in the future, offering both cultural richness and health benefits to a broader audience.

Conclusion

Jauhah, the traditional fermented sticky rice dish of the Rongmei tribe, stands as a significant cultural artifact intertwined with social, religious, and health practices. Its preparation process, deeply rooted in tradition, highlights the ingenuity of the Rongmei people in utilizing natural fermentation for food preservation. Jauhah's rich probiotic content and digestive enzymes contribute to the overall health and well-being of the community, making it not just a food item but a symbol of longevity and resilience. Culturally, Jauhah remains a sacred dish, served during social gatherings and rituals, cementing its importance in community building and cultural preservation. The fermentation process itself, passed down through generations, reflects the deep connection between food, environment, and tradition.

Volume: 04 Issue No: 12

DIGITAL VIDEO - AN EFFECTIVE DIGITAL EXTENSION TOOL

Article ID: AG-VO4-I12-38

***Arun Kumar S and Amtul Waris**

ICAR- Indian Institute of Rice Research, Hyderabad – 500030, India

*Corresponding Author Email ID: arunswarnaraj@gmail.com

Introduction

In recent years, digital technologies have significantly transformed agricultural extension services, enabling farmers to access critical information and support through various innovative digital tools. Among various digital tools, video remains as one of the powerful and effective tools. It utilizes video-based agricultural content to deliver agricultural knowledge directly to farmers. The visual and audio elements and appeal of the video makes it possible to become one of the powerful digital tools in the extension professional's kit. Video Extension not only enhances learning but helps in making complex agricultural practices easier to understand and apply by farmers with any level of education. It remains very effective in reaching remote and rural farmers who may face challenges in accessing traditional non-digital extension services. By following a systematic approach, Video Extension can improve the skills and knowledge of farmers and empower them to make informed decisions for increasing their farm productivity and sustainability in agriculture.

Why Video Extension?

Traditional agricultural extension methods are mostly the foundational approach to sustainable rural development today face several operational limitations that hinder their effectiveness. These approaches relied mostly on face-to-face interactions owing to its resource-intensiveness and because of time-consuming nature. Limited access to extension machinery at grass root levels, especially in regions with low infrastructure led to lack of access to extension support for the farmers. Also, traditional methods failed to address the diverse needs of farmers, particularly those with low literacy levels or different learning styles, as they primarily deployed written materials or other verbal communication. The high costs involved in organizing the group methods like workshops or field visits further limit the reach of traditional extension services, making it difficult to scale up efforts. Due to this, there is an information gap among many of the farming stakeholders for the want of the latest agricultural techniques and innovations. such gaps are negatively impacting their productivity and sustainability.

Videos, especially digital ones, help to meet the challenges of disseminating information to farmers and reaching the poor, marginalized, women, and rural youth. Some uses of video in agriculture include raising awareness, stimulating demand for support, farmer-to-farmer extension, training on agricultural innovations, stimulating creativity, and as a tool for documenting and monitoring and evaluation (M&E).

Agricultural extension through digital video has emerged as an important option in the extension strategies and is used as a powerful tool for education and training, offering several advantages over traditional extension methods. In today's digital era, one of the key benefits that digital video approach offers are its accessibility. Video content can be accessed at any point of time, from any location, allowing learners to engage with the selected content or learning material at their convenience. This gains importance for extension in rural or remote areas where face-to-face interactions are not always feasible. The possibility of revisiting the content when required for further understanding and clarity enhances the learning retention (Knowles, 2021). With video, one of the significant advantages is its ability to demonstrate complex processes visually and in simple terms. Especially in the agricultural domain, it helps to show the complex process like planting, pest management, or machine operations as simple step-by-step procedures. It helps the extension professionals in making abstract concepts easier to grasp. The eye catch visual representation improves the learner's ability to apply knowledge in real-life settings. Beyond the audio-visual content, digital video often allows for interactivity, such as quizzes, discussion forums, or the ability to pause and rewind the content thereby providing an active learning environment.

What favours deployment of digital videos as an effective digital extension tool?

In today's context, the scope for deploying video as an effective digital extension tool for Indian farmers is vast, particularly given the country's two decades' rapid digital transformation. India has witnessed a sharp increase in internet penetration, especially in rural areas, owing to affordable mobile data and widespread smartphone use. As of 2023, India had over 750 million internet users, with a significant portion of these users relying on mobile devices for internet access (Statista, 2023). This digital accessibility advantage presents a unique opportunity for video-based extension services not only in agriculture but also in other sectors like education and health. Government initiatives like the Digital India campaign and the Pradhan Mantri Gramin Digital Saksharta Abhiyan are already bridging the digital divide and expanding the potential reach of video-based educational content.

As a significant number of Indian farmers live in rural and remote areas, they rely on informal sources such as peers and local markets for agricultural advice leading to poor extension advisory services like outdated or inaccurate information (ICAR, 2021).The scope for deploying video as an effective digital extension tool for Indian farmers is particularly promising in today's context, as it ensures not only access to reliable sources but also addresses several key challenges that farmers face like limited access to timely and accurate information. Video-based digital content from validated sources are accessible today through mobile devices, and has the potential to bridge this gap by providing farmers with up-to-date, scientifically accurate information in easily and clearly understandable format. Furthermore, with the advantage of having higher engagement rate compared to other forms of digital content, videos are counted as particularly suitable for rural farmers and communities with low literacy levels. There is evidence that its strategic usage has shown increased adoption of technology dealt in videos when presented with visually rich and easy-to-understand content (IFPRI, 2022).

Additionally, platforms like YouTube, instagram and WhatsApp, which are currently in-vogue in India, provide an accessible infrastructure for distributing video-based content. These mediums can also facilitate community interaction, where farmers can share experiences and solutions through video forums, enhancing peer learning. In this way, video extension can bridge the knowledge gap in rural areas and empower local communities with crucial, timely information.

Harnessing Video Technology for Sustainable Agricultural Practices - Case of Digital Green

Digital Green's use of digital videos in agriculture is a case representation of successful integration of technology with traditional/modern knowledge through participatory approach and providing a scalable and effective solution to agricultural challenges in rural India. Digital Green, which was launched in 2008, is an impactful initiative in India that leveraged digital technology to improve agricultural practices and disseminate knowledge to rural farmers using a platform that deploys digital videos on information about best farming practices. It followed the principle of peer-to-peer learning and encouraged farmer-to-farmer knowledge exchange. It came to limelight for use of participatory approach in production and distribution of short, locally relevant videos supported with mediated instructions for topics of agricultural importance and screened locally using low cost digital projectors.

Points to be considered

Deploying videos as an effective agricultural extension and learning tool should be considered with following key factors in mind to ensure best results and impact.

1. **Relevant content:** Tailored videos with specific felt needs of the targeted audience covering the challenges locally faced by the stakeholder.
2. **Right format:** Select the right type of video format as per the need like farmer- learning videos (made with farmers), participatory videos (made by farmers), instructional (developed mainly by researchers/ extension professionals with limited input from farmers), documentary (for describing events), institutional (promoting a project or an organisation) is very important.
3. **Engaging Visuals and Demonstrations** -Videos that use visuals and showcase practical, hands-on examples of best practices in crop production and management can be more engaging.
4. **Language and Communication Style** - Localised video content presented in local languages and dialects can connect easily and ensure maximum understanding. Care should be taken to use simple and clear language, avoiding technical jargon, to make the content understandable to a wide range of viewer-farmers with varying literacy levels.
5. **Peer-to-Peer vs expert-driven content** - Videos that feature progressive farmers who have successfully implemented certain practices are often more effective than expert-driven content. Peer-to-peer learning fosters trust, increases the rate of adoption.
6. **Multi-platform accessibility** - videos not only accessible/available on multiple platforms and complying to different formats that are optimised for low data usage will have better viewership.
7. **User Engagement and Interaction** - User engagement efforts should be followed from video planning stage and videos that encourage interaction in the form of asking

questions, sharing experiences and participation in discussions can lead to effective learning

By considering the above said factors along with cultural consideration, digital videos can become a highly effective tool in agricultural extension and learning, improving farming practices and enhancing productivity in rural communities.

Conclusion

Digital video has emerged as a powerful and effective tool for agricultural extension by offering a dynamic and engaging medium to deliver critical information to farmers. The ability to deliver localized, culturally relevant, and easily understandable content has made digital video a game-changer in improving agricultural practices and boosting productivity. By considering the factors like content relevancy, right format, participatory content development, multi-platform access, it can continue to play a pivotal role in transforming lives of its stakeholders leading to overall development of rural communities.

References

International Food Policy Research Institute (IFPRI). (2022). *Digital Extension Services in India: Improving Agricultural Productivity*. Retrieved from https://www.ifpri.org

Indian Council of Agricultural Research (ICAR). (2021). *Report on Agricultural Extension in India*. Retrieved from https://icar.org.in

Knowles, M. (2021). The Adult Learner: The Definitive Classic in Adult Education and Human Resource Development. Routledge.

Statista. (2023). *Number of Internet users in India from 2015 to 2023*. Retrieved from https://www.statista.com/statistics/255146/number-of-internet-users-in-india/

Volume: 04 Issue No: 12

PROMISING BARNYARD MILLET VARIETIES RELEASED FOR CULTIVATION IN INDIA

Article ID: AG-VO4-I12-39

[1*]Krishnan, V., [2]R. Praveen, [2]K. Preetha, [2]FS. Aparna, [2]S. Lakshmipriya and [2]J. Arathi,

[1]Faculty & [2]PG ScholarPandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

Barnyard Millet (*Echinochloacrusgalli, E. colona*), is a short duration crop that can grow in adverse environmental conditions with almost no input and can withstand various biotic and abiotic stresses. In addition to these agronomic advantages, the grains are valued for their high nutritional value and lower expense as compared to major cereals like rice, wheat, and maize. It contains a rich source of protein, carbohydrates, fiber, and, most notably, micronutrients like iron (Fe) and zine (Zn) that are related to numerous health benefits. These features make barnyard millet an ideal supplementary crop for subsistence farmers and also as an alternate crop during the failure of monsoons in rice/major crop cultivating areas.

1. Anurag: This is a pure-line selection from Gorakhpur local, released by CSAUA&T, Kanpur, Uttar Pradesh in the year 1985 for cultivation in Central and Eastern Uttar Pradesh. It is a medium tall plant, round stem and with pubescence. It produces synchronous tillering and dark green leaves. It produces a greater number of racemes (35-40). The panicles are erect with purple pigmentation before maturity and curved and grey at maturity. The grains are grey coloured with test weight of 2.8-3.0 g. It is tolerant to pink borer. It matures in 85-90 days and yield 15-17 q/ha.

2. Co 1: This is a pure-line selection variety, released by Tamil Nadu Agricultural University, Coimbatore in 1982, for cultivation in Tamil Nadu. This is a profuse tillering plant with stay green character and medium in maturity (85-90 days). It produces loose, spear shaped panicle and white coloured grains. It matures in 85-90 days, yield 16-17 q/ha).

3. Co (KV) 2 (TNAU 43): This is a pure-line selection from EF 79, released by Tamil Nadu Agricultural University, Coimbatore in 2009, suitable Kharif rainfed conditions in Tamil Nadu. This an erect plant with profuse tillering habit and narrow leaves; cylindrical compact panicles with purple pigmentation; non-lodging, maturing in 95-100 days, high yielding (21-22 q/ha) and suitable for contingency planting. It has long cylindrical compact branched panicles that produces brownish grey-coloured bold grains.

4. DHBM 23-3: It is a cross derivative of EF 8 x IEC 566 released in 2019 by UAS, Dharward, Karnataka for rainfed kharif cultivation in Andra Pradesh, Karnataka, Madhya Pradesh and Tamil Nadu. It has thin stems with heavy tillering capacity. It produces semi-compact panicles with glumes pigmented at maturity. It is tolerant to shootfly and resistant to head and grain smut. It is a dual-purpose variety with grain yield of 30-32 q/ha and fodder yield of 6.5-6.7 t/ha. It is a medium duration crop.

5. DHBM 93-3: It is a cross derivative of VL 13 x IEC 566 released in 2016 by UAS, Dharward, Karnataka for rainfed kharif cultivation in all states except Uttarakhand and Himachal Pradesh. It has sturdy tillers with lodging resistance. It produces pale green leaves and compact panicles. It is tolerant to shootfly and resistant to head and grain smut. It is a dual-purpose variety with grain yield of 22-24 q/ha and fodder yield of 5.5-6.5 t/ha. It is a medium duration crop.

6. ER 64 (Pratap Sawani 1): This is a pure-line selection from local variety, released by MPUA & T, Udaipur, Rajasthan for cultivation in Rajasthan. The plant is 20-130 cm tall, with broad; leaves, producing 4-5 productive tillers and semi-compact long panicles of 15-20 cm length. The inflorescence is with purple pigmentation. The plant is resistant to smut and tolerant to shootfly. It matures early (85-90 days). This is a dual-purpose variety that gives grain yield of 15-17 q/ha and fodder yield of 5.0-5.5 t/ha.

7. Gujarati Banti 1: It is a pure-line selection variety developed by GAU, Surat, Gujarat in the year 1984, for cultivation in hills of South Gujarat. It is a medium tall plant with medium duration (85-90 days), yielding 18-20 q/ha. It produces long panicles with yellowish white-coloured grains. It is free from major pest and diseases.

8. K 1: This is a pure-line selection from Tenkasi local, released by RRS, Kovilapatti, Tamil Nadu Agricultural University, Coimbatore in the year 1970 for cultivation in Tamil Nadu. It is a tall plant (130-140 cm), with purple pigmentation on nodes and is susceptible to lodging. It produces loose spear shaped panicle with dull white coloured grains. It is medium in duration (85-90 days) and yielding 5-10 q/ha.

9. K 2: This is a pure-line selection variety released by RRS, Kovilapatti, Tamil Nadu Agricultural University, Coimbatore in the year 1978 for cultivation in Tamil Nadu. It is a tall plant (125-130 cm), with purple pigmentation on nodes and is susceptible to lodging. It produces loose panicle with dull white coloured grains. It is medium in duration (85-90 days) and high yielding (20-23 q/ha).

10. KE 12 (Chandan): It is a pure-line selection, developed by CSAUA & T, Kanpur, Uttar Pradesh in 1989 for cultivation in the plains of Uttar Pradesh. It is an erect plant with strong thick glabrous stem, with fistular internode and prominent nodes; tightly covered with leaf sheath. The leaves are broad with pinkish margin. It produces purple pigmented panicles that turn grey at maturity. The panicle is erect, compact elongated with more racemes. It matures very early in duration (70-75 days) and yielding 12-16 q/ha.

11. KE 33 (Kanchan): It is a pure-line selection, developed by CSAUA & T, Kanpur, Uttar Pradesh in 1993. It produces synchronous tillering with semi-compact drooping panicles. It is resistant to grain smut and very early in duration (65-70 days) and yielding 15-16 q/ha.

12. MDU 1: This is a pure-line selection from Arupukottai local, released by AC & RI, Madurai, TNAU, Coimbatore in the year 2017 for cultivation in Southern districts of Tamil Nadu. It produces compact pyramidal shaped panicles. The grains have high iron content (16 mg/100g), high milling per cent (70), good cooking quality and taste. It matures in 95-100 days and yield 15-17 q/ha.

13. PRJ 1 (*Echinochloa esculenta*): This a Japanese Barnyard millet (*Echinochloa esculenta*) and is a pure-line selection from exotic germplasm line IEC 542, released by GBPUA& T, Raichauri, Uttarakhans in 2003. The plant is dwarf with dark foliage, broad erect leaves; curved panicles with slight awn producing beaked grains. This variety is resistant to grain smut and matures in 115-120 days and yield 23-25 q/ha.

14. RAU 11 (Sushrutha): This is a pure-line selection variety, jointly released by RAU, Pusa, Samastipur, Bihar, ICAR-IARI, New Delhi and ARS, Hanumanamatti, Karnataka in the year 2000 for cultivation in Zone 8 of Karnataka. This an erect plant with profuse tillering and producing compact panicles. It matures early (75-80 days) and high yielding (20-22 q/ha).

15. RAU 3: This is a pure-line selection variety, released by RAU, Dholi, Bihar in the year 1985 for cultivation in Bihar. The plant is tall (110-120 cm), producing 2-3 basal tillers, broad leaves with purple pigmented margin and on panicle. The panicles are erect at emergence and curved at maturity. It matures early (80-85 days) and high yielding (18-22 q/ha).

16. VL Madira 172: It is a cross derivative of EF 2 x VHC 5205, released by VPKAS, Almora, Uttarakhan in 2000, for cultivation in Uttar Pradesh, Gujarat and Karnataka. It is a non-lodging, non-shattering, producing open pyramidical shaped erect panicles. It is resistant to grain smut. It matures in 75-80 days and yield 22-23 q/ha.

17. VL Madira 181: It is a cross derivative of ECC 27 x VL 60, released by VPKAS, Almora, Uttarakhand in 2001, for cultivation in Bihar, Karnataka, Madhya Pradesh, Uttarakhand and Tamil Nadu. It is a profuse tillering, producing 3-4 productive tillers. The panicle is slightly droop and cylindrical in shape with spikelets arranged in four alternate rows. It matures in 70-80 days and yield 16-18 q/ha.

18. VL Madira 207: It is a cross derivative of VL 171 x GECH 506, released by VPKAS, Almora, Uttarakhan in 2008, for cultivation in Uttarakhand. It is a non-lodging, non-shattering plant type with high harvest index. It produces pyramidical shaped panicles. It matures in 80-90 days and yield 16-18 q/ha.

19. VL Madira 21: It is a pure-line selection from Gharwal local variety, released by VPKAS, Almora, Uttarakhand in 1990, for cultivation in Uttar Pradesh. It is an erect tall plant (120-130 cm), susceptible to lodging. It produces 3-4 semi-compact panicles of 20-25 cm length with 35-40 racemes. The panicle is slightly purple pigmentation. It matures in 80-90 days and yield 25-30 q/ha. It is rich in protein (6.75-7.0 %).

20. VL Madira 29: It is a pure-line selection from VHC 5360-1, released by VPKAS, Almora, Uttarakhand in 1988, for all Barnyard millet cultivation areas of the country except Andra Pradesh and Tamil Nadu. It is an erect plant of 95-100 cm tall, producing long, compact and curved panicles with slight purple pigmentation. It matures in 80-90 days and yield 25-26 q/ha.

21. VL Madira 8: It is a pure-line selection variety, released by VPKAS, Almora, Uttakhand in 1982, for cultivation in Hills of Uttar Pradesh. It produces long, incurved, compact cylindrical shaped panicles. It matures in 85-90 days and yield 18-20 q/ha.

PURE-LINE SELECTION VARIETIES

Most of the early developed varieties of Barnyard millet were based on pure-line selections from germplasm accessions of either local varieties or of exotic nature. Examples of pure-line varieties developed in Barnyard millet are presented in Table 1 below.

Table 1. Important pure-line selection varieties released for cultivation in India

Sl. No.	Pure-line variety	Selection source	Institute involved
1.	Co 1	Local collections	TNAU, Coimbatore, Tamil Nadu
2.	Co (KV) 2	EF 79	TNAU, Coimbatore, Tamil Nadu
3.	K 1	Thenkasi local	RRS, Kovilpatti, TNAU, Tamil Nadu
4.	K 2	Local collection	RRS, Kovilpatti, TNAU, Tamil Nadu
5.	MDU 1	Arupukottai local	RRS, Arupukottai, TNAU, Tamil Nadu
6.	VL Madira 8	Local collection	VPKAS, Almora, Uttarakhand
7.	VL Madira 21	Gharwal local	VPKAS, Almora, Uttarakhand
8.	VL Madira 29	VHC 5360-1	VPKAS, Almora, Uttarakhand
9.	Anurag	Gorakhpur local	CSAUA&T, Kanpur, Uttar Pradesh
10.	Gujarat Banti 1	Surat local	GAU, Surat, Gujarat
11.	RAU 3	Local collection	RAU, Dholi, Bihar
12.	RAU 11 (Sushrutha)	Local collection	RAU, Pusa, Bihar, ICAR-IARI, New Delhi & ARS, Hanumanamatti, Karnataka

13.	KE 12 (Chandan)	Local collection	CSAUA&T, Kanpur, Uttar Pradesh
14.	KE 33 (Kanchan)	Local collection	CSAUA&T, Kanpur, Uttar Pradesh
15.	PRJ 1(Japanese Barnyard millet)	IEC 542	GBPUA&T, Raichur, Uttarakhand
16.	ER 64 (Pratap Sawan 1)	Local collection	MPUA&T, Udaipur, Rajasthan

PEDIGREE BREEDING VARIETIES

With the advancement of technologies and bringing recombination breeding efforts to combine two parents has brought high yielding cultivars in barnyard millet.

Table 2. Important Pedigree method varieties released for cultivation in India

Sl. No.	Pedigree variety	Parentage	Institute involved
1.	VL Madira 207	VL 172 x GECH 506	VPKAS, Almora, Uttarakhand
2.	VL Madira 181	ECC 27 x VL 60	VPKAS, Almora, Uttarakhand
3.	VL Madira 172	EF 2 x VHC 5205	VPKAS, Almora, Uttarakhand
4.	DHBM 93-3	VL 13 x IEC 566	UAS, Dharward, Karnataka
5.	DHBM 23-3	EF 8 x IEC 566	UAS, Dharward, Karnataka

Volume: 04 Issue No: 12

INDIAN ASH TREE- AN INDIGENOUS GREEN LEAF MANURE TREE

Article ID: AG-VO4-I12-40

[1]A. Anuratha and [2*]V. Krishnan

[1]Faculty, Agricultural College and Research Institute, Keezhvekur, Nagapattinam District, 611104, Tamil Nadu

[2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

Indian ash tree is botanically called *Lannea coromandelica* (2n: 58). Belonging to family Anacardiaceous. It is also called Gurjon tree, Woodier tree, which is a multipurpose tree that is commonly found in South and Southeast Asia, ranging from Sri Lanka to Southern China. It grows as a small tree up to 10 meter tall in dry woodland environment and as a large spreading tree up to 25 meters tall under moist humid, sunny condition. Found distributed in Andaman & Nicobar Island, Andhra Pradesh, Assam, Bihar, Kerala, Maharashtra, Madhya Pradesh, Odisha, Punjab, Uttar Pradesh and throughout Assam.

BOTANICAL DESCRIPTION OF INDIAN ASH TREE

Habitat: Grows well in tropical and sub-tropical zones up to an elevation of 18000 meters. It comes up well under sunny condition.

Habit: Deciduous tree, grow to to 25 m high,

Root: Deep tap root

Stem: Branchlets are minutely covered with stellate-rusty tomentose starry hairs. Bark surface grey to dark brown, rough, exfoliating in small irregular flakes, fibrous; blaze crimson red or deep pink; exudation gummy, red.

Leaves: Imparipinnate, alternate, clustered at the end of branchlets, estipulate; rachis 21-27 cm, stout, swollen at base, stellate-hairy pubescent when young; leaflets 7-11, opposite; petiolule 3-5 mm, slender, pubescent; lamina 5-12 x 3-8 cm, oblong, oblong-ovate, oblong-lanceolate or ovate, base oblique, acute or round, apex acuminate, margin entire, lower surface and part of the upper with scattered stellate pubescence, chartaceous; lateral nerves 10-16 pairs, parallel, prominent, puberulent beneath, intercostae reticulate, prominent.

Inflorescence: Indian ash tree is dioecious. Male and female trees seperate. Flowers are unisexual, greenish, the male in compound racemes and female in simple racemes.

Male Flowers: Unisexual, yellowish-green; 8 mm across; calyx 4-lobed; lobes ovate, imbricate, persistent; petals 4, lanceolate, reflexed, imbricate; disc annular, 8-lobed; stamens 8, inserted below the disc, filaments unequal, subulate, ovary abortive.

Female flowers : In simple racemes; calyx 4-lobed; lobes ovate, imbricate, persistent; petals 4, lanceolate, reflexed, imbricate (petals and sepals as in male flowers); stamens very short and small; anthers sterile; ovary superior, ovule pendulous from near the top of the cell.; styles 4; stigma peltate.

Fruit: A drupe, 12 mm long, ovoid, red; stone hard.

Seed: Kidney shaped single seed in compressed condition.

Pollination: Cross pollination due to unisexual flowers.

Center of origin: Indo-Malaysia and China

RELATED SPECIES

Lannea acida

Lannea microcarpa

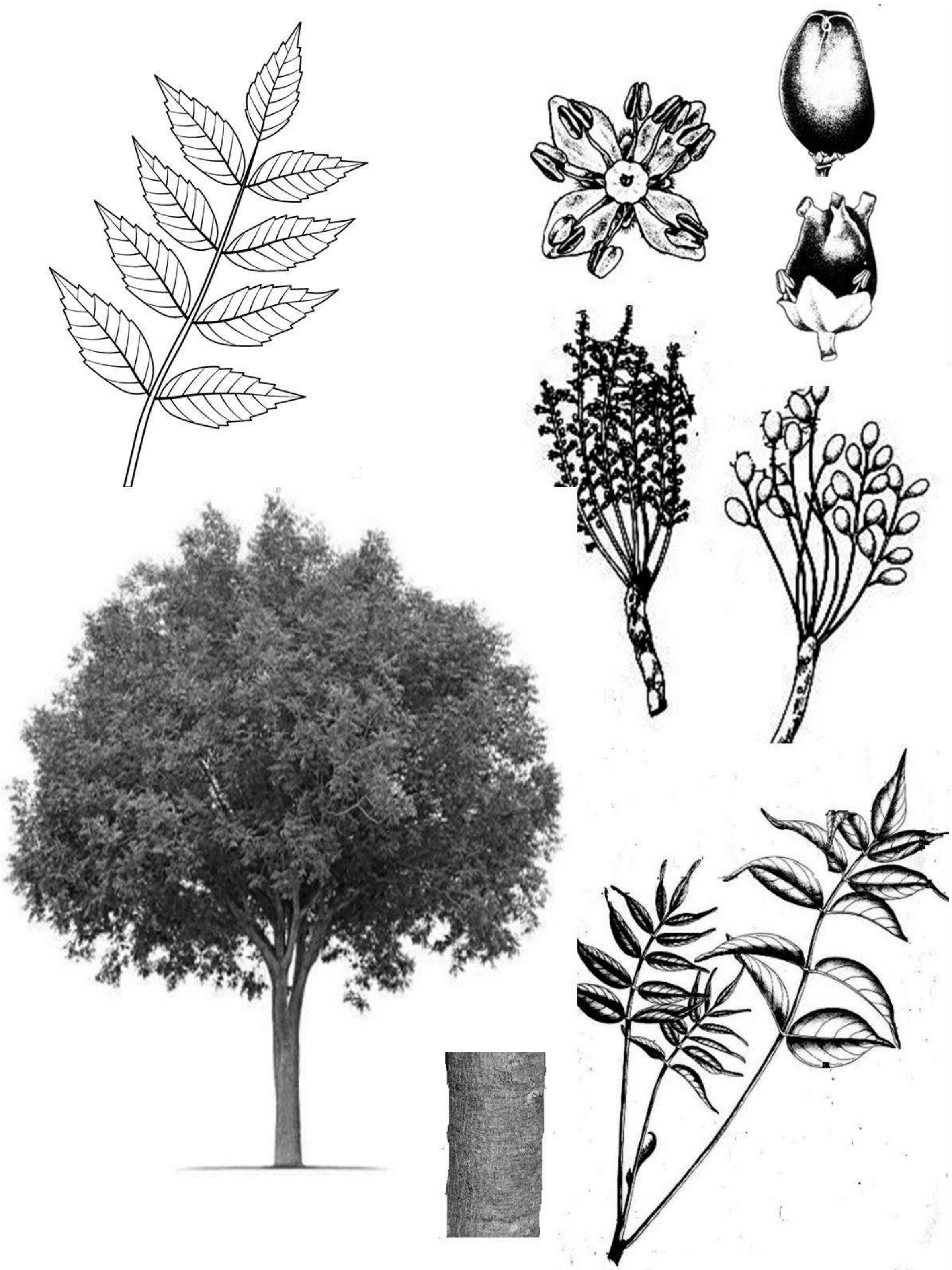
Lannea. discolor

Lannea edulis

Lannea. tranulta

USES OF INDIAN ASH TREE

1. Indian ash tree yield enormous quantity of green leaf manure, especially for rice crop.
2. The gum excudate from the stem bark is used for paper sizing and in Calico printing.
3. The wood is also used for carving, turnery and for making certain furnitures.
4. Tender shoots are releished by elephants and the leaves are eaten by cattle.
5. The crows are fond of fruits.
6. Young leaves and sprouts are eaten raw or as cooked green vegetable.
7. They can be grown as hedge trees as a live fence.



8. The bark contains tannins and it is used for tanning leather.
9. The bark yields coarse fiber.
10. The heartwood is used for spear shafts, wheel spokes, oil presses and grain pounders.
11. The wood is used as good fuel wood and produce minimal smoke.
12. The bark extract is used as an astringent in traditional medicine to cure bleeding gums and in controlling diarrhoea.
13. The crushed fruits are mixed in water to stupify fish for catching.
14. The wood is used for making packing cases.

ADVANTAGES OF INDIAN ASH TREE

1. It yields enormous green leaf manures for wetland soil to be puddled in the soil.
2. It can be easily propagated by stem cuttings of even large branches that easily set root.
3. It can tolerate a temperature range between 8 to 470C.
4. It can grow well in poor marginal soils and wastelands.
5. The tree is resistant to fire.
6. It is an excellent termite resistant tree.
7. It can grow into a large tree up to 25 meters tall under moist humid sunny environment.

LIMITATIONS OF INDIAN ASH TREE

1. Its seed viability is short lived and need to be sown as soon as possible.
2. Under dry woodland condition it grows only upto 10 meters tall.
3. The tree is dioecious and hence need to plant male and female trees to get seed.

GREEN LAEF MANURE VALUE OF INDIAN ASH TREE

Indian ash tree produces copious quantity of green leaf yield throughout the year, except during autumn season. It pollards fairly well and the rate of regrowth of coppice is fast. The leaf contains crude protein 5.10%, crude fiber 4.15% and minerals 2.96%. Nitrogen 2.78%, Phosphorous 1.4% and Potassium 3.2%. The green leaf yield is around 350 to 400 kg per annum.

Volume: 04 Issue No: 12

ACCIDENTAL EXPOSURE OF FARMERS TO HERBICIDES AND ITS OBSERVABLE HEALTH EFFECTS IN THE AKOLA REGION

Article ID: AG-VO4-I12-41

***Dr. Priyanka M. Ramteke**
Assistant Professor, Department Zoology
Shri Shivaji Science College, Amravati
Shivaji Nagar, Morshi Road , Amravati 444603, India
*Corresponding Author Email ID: priyanka.ramteke753@gmail.com

Abstract

Herbicides are indispensable for modern agriculture, offering cost-effective and efficient weed control. However, their excessive application raises serious concerns about environmental pollution, bioaccumulation, and adverse health effects. This study examines the sub-chronic toxic effects of six commonly used herbicides—2,4-D, Atrazine, Glyphosate, Pursuit, Fluoxetine, and Paraquat—based on interviews with 15 farmers in the Akola region (Maharashtra) from June 2023 to February 2024. The farmers reported symptoms ranging from mild skin irritation and dizziness to severe complications like vision loss, respiratory distress, and liver damage. The study highlights the urgent need for stricter regulations, protective measures, and awareness programs to mitigate health risks associated with herbicide exposure.

Keywords: Glyphosate, Paraquat, Herbicide residue, Environmental safety, Health implications

Introduction

Herbicides have become a cornerstone of agricultural practices, particularly with increasing labor costs and the need for effective weed control. Since the discovery of 2,4-D post-World War II, herbicide use has surged globally. In India, their usage has risen by 30% in the last decade, reflecting their critical role in weed management. However, excessive herbicide application is linked to significant challenges, including soil and water contamination, harm to non-target organisms, and potential health hazards due to residue accumulation in produce.

The primary objective of this study was to understand the health implications of accidental herbicide exposure on farmers in Akola and raise awareness about the importance of safe herbicide use.

Herbicides and Their Health Effects

Several herbicides studied in this research—2,4-D, Atrazine, Glyphosate, Pursuit, Fluoxetine, and Paraquat—are known for their efficacy but also for their toxic effects:

- **2,4-D:** Causes chronic symptoms like muscle twitching and respiratory irritation.
- **Atrazine:** Associated with skin issues, blisters, and vision impairment.
- **Glyphosate:** Leads to nausea, dizziness, respiratory problems, and potential long-term organ damage.
- **Pursuit:** Known for causing headaches, dizziness, and liver complications.
- **Fluoxetine:** Causes nervous system effects, including weakness, dizziness, and nausea.
- **Paraquat:** Highly toxic, with symptoms such as vomiting, diarrhea, and pulmonary damage.

Methodology

Fifteen farmers were interviewed between June 2023 and February 2024, focusing on their herbicide spraying practices and resulting health symptoms. The herbicides used and their effects were documented to draw correlations between exposure and health outcomes.

Data collection included:

1. Farmer interviews on herbicide usage and handling.
2. Observation of symptoms post-exposure.
3. Cross-referencing with existing literature on herbicide toxicity.

Results and Discussion

Farmers in the Akola region reported diverse health issues based on the herbicide used:

- **Glyphosate:** Farmers experienced eye irritation, vision loss, cold-like symptoms, and skin rashes. Similar effects, including gastrointestinal irritation and headaches, were reported in prior studies.
- **Atrazine:** Exposure caused nausea, blistering, and skin problems, consistent with its toxicological profile.
- **2,4-D:** Symptoms included dizziness, nausea, and temporary vision impairment, with studies linking it to respiratory irritation.

- **Pursuit:** Chronic exposure led to severe symptoms like slurred speech, seizures, and liver damage.
- **Paraquat:** Farmers reported immediate effects, including vomiting, diarrhea, and respiratory issues. This aligns with its known toxicity, even at low exposure levels.

The findings reveal that improper handling and lack of protective measures amplify health risks. Herbicides, especially persistent ones like Paraquat and Atrazine, pose long-term risks due to bioaccumulation in the environment.

Conclusion

While herbicides are essential for modern agriculture, their unsafe use leads to significant health risks for farmers and environmental contamination. The study emphasizes the need for:

1. **Regulation:** Stricter policies governing the sale and use of hazardous herbicides.
2. **Awareness Programs:** Educating farmers about protective equipment and safe application methods.
3. **Environmental Monitoring:** Regular assessments of herbicide residues in soil and water to prevent bioaccumulation.

The widespread use of herbicides in public spaces should also be re-evaluated to protect both human health and the environment.

Call to Action:

Immediate steps are needed to enforce safer herbicide practices and raise awareness among farming communities. By adopting sustainable agricultural practices, we can mitigate health risks and ensure environmental safety for future generations.

References

Adam A, Marazuki A, abdul RahmanA and Abbdul Aziz M. Department of pharmacy, faculty of applied health Sciences, university Malaysia. J. Human toxicology. 1997;39(3) :147-51

Agarwal R, Srinivas R, Aggarwal AN and Gupta D.. Experience with parquet poisoning in a respiratory intensive care unit in North India. Singapore Medical Journal 47(12): 2006;1033-1037.

Anon. Monsantigulty in 'false ad row'.; BBC News *http;/) news. Bbcco. Uk/2/hi/ereope/8308903stm;* 2009.

Avi varna reported paraquate poisoning gramoxone toxicity and side effects https:www.heathline comm; 2022

Joachim f. Wernicke safety and side effects profile of fluxine entine.; 2004 .

Dwivedi S, Saquib Q, Abdulaziz A, Al-Khedhairy, Musarrat J.Butachlor induced dissipation of mitochondrial membrane potential oxidative DNA damage and necrosis in human peripheral blood mononuclear cells. Toxicology 302(1): 2012;77-87.

E X T O X N E T Extension Toxicology Network Pesticide Information Profiles 1996**.**

Khosya S and Gothwal S.. Two cases of paraquat poisoning from kota, Rajasthan, India case reports in critical care. 2012; ID 652146.DOI. 10.1155/2012/652146.

Material safety dada sheet. U.S.OSHA Hazard Communication Standard, 29CFR1910.1200 and Canada Workplace Hazardous Materials Information System (WHMIS); 2009.

Panneerselvam N, Sinha S and Shanmugam G..Genotoxicity of the herbicide fluchloralin on human lymphocytes in vitro, chromosomal aberration and micronucleus tests. Mutation Research Genetic Toxicology 34(1&2): 1995,;69-72

Pommery J.Mathieu M.Mathieu D *et, al.,* Atrazine in plasma and tissue following Atrazineaminotrizole- ethylene glycol-formaldehyde poisoning.J.Clin Toxicol. 1993;31(2) :323-331.

Sandhu JS, Dhiman A, Mahajan R and Sandhu P.. Outcome of paraquat poisoning – a five year study. Indian Journal of Nephrology 13, 2003; 64-68.

Senarathna L and Eddleston MF.. Prediction of outcome after paraquat poisoning by measurement of the plasma paraquat concentration QJM 102(4): 2009;251-259.

Singh SB, Yaduraju NT and Kulshrestha G. Terminal residues of fluazifop-p-butyl in soybean. Annals of Plant Protection Sciences 7,1999.

Zacharias E Suntres. Role of antioxidants in paraquat toxicity. Toxicology volume180 issue12002 ;pages 65-77.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

INDIGENOUS TECHNICAL KNOWLEDGE IN FOREST CONSERVATION – A STEP TOWARDS NATURAL RESOURCE MANAGEMENT

Article ID: AG-VO4-I12-42

***T. Ram Sundar and M.Manikandan**

*[1]Assistant Professor, Department of Agricultural Extension Education, Institute of Agriculture Research Technology, NMV University, Muthuramalingapuram, Tamil Nadu – 626 126

*2 (Pg Scholor), Department of Agricultural Extension Education,
Institute of Agriculture Research &Technology, NMV University
Muthuramalingapuram, Aruppukottai-626105, Tamil Nadu, India

*Corresponding Author Email ID: sundarramluck@gmail.com

Abstract

The role of Indigenous Technical Knowledge (ITK) in forest conservation is vital for sustainable natural resource management. This paper explores the contributions of ITK, with a focus on indigenous tribes in Tamil Nadu and Karnataka, such as the Toda and Soliga communities. These tribes have developed time-tested practices that ensure the conservation of biodiversity, soil, and water resources. Practices such as controlled burning of grasslands, rotational grazing, and the preservation of sacred groves, like the "munds" of the Todas, have been central to maintaining ecological balance. Similarly, the Soligas engage in sustainable harvesting of forest produce and employ forest fire management techniques to protect the forest ecosystem. Despite the advancements in science and technology, these traditional methods are increasingly recognized for their resilience and long-term sustainability. However, there are challenges in implementing ITK, including barriers posed by modernization and limited integration into contemporary forest management policies. By fostering collaboration between indigenous communities and government agencies, traditional knowledge can be incorporated into modern conservation efforts. This approach has the potential to not only preserve the environment but also safeguard cultural heritage. The paper concludes that combining ITK with modern conservation strategies offers a robust framework for sustainable natural resource management, particularly in forest

ecosystems. Through such efforts, we can promote ecological resilience, biodiversity, and community empowerment in managing natural resources.

Keywords: Indigenous Technical Knowledge (ITK), Forest Conservation, Sustainable Resource Management and Tribal Communities

1.Introduction

The evolution of earth over the billion years was astonishing with unimaginable changes. Modern forest was introduced nearly 12,000 years ago. Even the evolution of forest is something interesting in modern days. There comes a thought why is it so interesting, because there was a huge destruction of natural resources by the human activities like deforestation, depletion of water resources in the nearby forest arena and thereby affecting the flora and fauna within the forest but mother nature was always kind towards the actions of humans. In that note, the forest plays a pivotal role in maintaing the ecological balance to the environment even amid human activities both deliberate and unconsciousness. The ecological balance was brought out on grounds of maintaing the carbon mass in the atmosphere, soil conservation, water conservation and some of the forest trees are used as wood materials. They help to mitigate the climate change by absorbing the carbon that was emitted by the human activities and acts as a significant carbon sink. Forest is the home for beautiful plants and animals. Many medicinal plants are identified which helps to cure many diseases. They help to manage the effect of global warming by releasing water vapour and capturing rainfall. The mangrove forest plays a typical role in the coastal regions of Tamilnadu as they help to overcome the disasters made by cyclones and tsunamis. ITKs are the part and parcel of the living community along with traditional environmental structuring. Of late the policy makers and the researchers started recognising the value and importance of these ITKs in the day-to-day life of the rural and the tribal communities paving way for sustainable livelihood (Sandhiya, 2019)

1.1 Role of Indigenous technical knowledge in Natural resource management

We live in the modern era with the advancement of science and technology but still humans are in a situation to back their traditional ideas in managing the resources. Our ancestors have come out with their own scientific knowledge and there is lot more evidences that their ideas in conserving the resources is awesome. Indigenous Technical Knowledge (ITK) refers to the time-tested, sustainable practices developed by indigenous and local communities often passed down through generations to generations. It’s very important for the human race to follow up the Indigenous technical knowledge from their ancestors. Because many traditional practices are getting forgotten in modern years, advancement of science and technology is good but at the same time we should stick on to the traditional practices. These practices are deeply rooted in understanding of local ecosystems, environmental patterns, biodiversity conservation and have long helped to maintain the delicate balance of nature. Mother nature will evolve over the years. The activities of the human by depleting the natural resources could be fatal for humans but not the nature, she will evolve.

Indigenous knowledge systems are adaptive and evolve in response to the environmental changes. Their practices such as mixed cropping, agroforestry and sustainable harvesting are now being recognized by modern science for their effectiveness in conserving resources and enhancing biodiversity. The revival and integration of ITK with modern natural

resource management approaches offer a pathway toward more resilient and sustainable ecosystems. As communities and policymakers grapple with the challenges of climate change, it is becoming increasingly clear that the wisdom embedded in indigenous practices holds valuable lessons for achieving long-term environmental sustainability. ITK is the information base for a society, which facilitates communication and decision-making. Indigenous information systems are dynamic and are continually influenced by internal creativity and experimentation as well as by contact with external systems. This knowledge system is usually not found in written form and it transmits from generation to generation through word of mouth. It includes experience, concepts, beliefs and perception and usually found in various folk forms. Its categories, construct and content differ from those of modern sciences. It is more closely linked to farming experience and captures much more than modern science. It encompasses the skills, experiences, and insights of people, applied to maintain or improve their livelihood (Sahely Kanthal, 2023)

In Tamil Nadu, as in many other parts of the world, indigenous communities have demonstrated remarkable insight into resource management. They have developed techniques to conserve water, manage forests and cultivate crops in ways that promote long-term sustainability. The Tribal groups of Tamil Nadu play a vital role in preserving the Indigenous technical ideas from generation to generation. Several experiments are taken by the farmers since long on trial-and-error basis on agriculture and allied activities to overcome the problems or adverse situations. The knowledge generated over the years is time-tested and has many attributes of eco-friendliness to farmers and nature. Such knowledge is called the “Indigenous

Technological Knowledge (ITK)" or "local knowledge "or "traditional knowledge" (Sasanka Lenka, 2020).

2. The Toda Tribes of Nilgiris

The Toda tribe of Tamil Nadu, residing primarily in the Nilgiri Hills, is one of the most distinctive indigenous groups in India, renowned for their sustainable practices in forest and grassland management. Their traditional pastoral lifestyle revolves around buffalo herding, which involves rotational grazing to maintain the balance between the shola forests and grasslands. This approach ensures the conservation of biodiversity while preventing overgrazing. The Todas also practice controlled burning of grasslands to prevent large-scale wildfires, a method that helps to maintain the health of the ecosystem. In addition, they preserve sacred groves or "munds," which are left untouched and serves as an ecological reserve, fostering the protection of endemic plant species. Their deep ecological knowledge is also reflected in the use of medicinal herbs and plants, further showcasing their harmony with the environment. The Toda people's semi-barrel-shaped huts, built using natural materials, reflect their sustainable architectural practices and their intricate embroidery known as "Pukhoor" has

gained a recognition as a Geographical Indication (GI) of India, preserving their cultural heritage. Despite facing the challenges from modern development and shrinkage of grazing lands, the Todas' indigenous technical knowledge is now being recognized for its pivotal role in conservation. Their practices are being integrated into modern ecological efforts to preserve the Nilgiri Biosphere Reserve, demonstrating the significance of Indigenous Technical Knowledge (ITK) in forest conservation and sustainable resource management. Their methods are increasingly seen as a vital knowledge in maintaining the ecological balance of the Nilgiris and thus making the Todas an exemplary model of how indigenous practices can contribute to sustainable natural resource management. Over the last fifty y ears this rotational grazing practice has almost ceased with the more static settlement of Toda people, and their growing adoption of agriculture. Since the 1882 Madras Forest Act, the Government has reserved certain forest. (Ramasubramanian,2019)

3. The Soliga Tribes of Karnataka

The Soliga tribe of Karnataka, much like the Toda tribe, practices sustainable forest and resource management deeply rooted in their cultural traditions. Living in the Biligiriranga Hills and Male Mahadeshwara Hills, the Soligas rely on shifting cultivation, sustainable harvesting of forest produces and controlled burning to prevent large-scale wildfires similar to the Todas' grassland management. Soliga tribal community has one of the few remaining forest-dwelling tribal communities in and around the forests in southern India. They live in settlements in and around the forests of B.R. Hills, M.M. Hills, and Bandipur in Karnataka (Logesh,2023). Their knowledge of medicinal plants and wildlife is extensive and they maintain a harmonious relationship with the forest, ensuring minimal disruption to the ecosystem. The Soligas also revere certain parts of the forest as sacred, preserving biodiversity through the protection of these areas. Their forest fire management techniques and sustainable harvesting methods contribute significantly to maintaining the balance of the ecosystem while allowing them to meet their subsistence needs. Like the Todas, the Soligas' traditional practices are now being recognized for their importance in conservation efforts, as they play a critical role in maintaining the ecological health of the forests they inhabit. Soligas are heavily dependent upon forest produce for their livelihood. Main occupation of Soligas is to collect minor forest produces like gum, honey, soap nuts, root and tubers, tamarind etc (Arun Somagond *et al.*,2020)

4. Barriers in implementing the Indigenous technical knowledge System

There is always a comparative analysis in taking up traditional practices in this modern era. With the advancement of science and technology, people often rely on modern methods to conserve natural resources, assuming them to be more effective. It is true that during disaster management, developed countries are well-equipped with modern early-warning systems and technologies that mitigate the impact of events like cyclones or earthquakes. However, when it comes to the sustainable conservation of natural resources, traditional practices have proven their resilience and effectiveness over centuries. Indigenous knowledge systems, passed down through generations, offer time-tested solutions tailored to local ecosystems. These practices focus on long-term ecological balance rather than short-term interventions, ensuring that natural resources are preserved not just for immediate use but for future generations. Embracing a balance between modern methods and traditional wisdom can create more holistic approaches to environmental conservation, as each has its strengths in protecting the planet.

5. Collaboration between indigenous communities and government agencies

Collaboration between indigenous communities and government agencies plays a crucial role in sustainable resource management and conservation efforts. Indigenous communities possess deep ecological knowledge and time-tested practices that are invaluable for maintaining biodiversity, preventing deforestation, and ensuring water conservation. When government agencies engage with these communities, they can integrate traditional wisdom into modern conservation policies, creating more effective and culturally sensitive approaches. Programs like joint forest management (JFM) or community-based natural resource management (CBNRM) have shown that such collaborations can empower local communities, improve resource management, and ensure better stewardship of natural ecosystems. Additionally, involving indigenous communities in decision-making fosters inclusivity, preserves cultural heritage, and enhances trust between local populations and governmental authorities, ultimately leading to more sustainable development outcomes.

Conclusion

Indigenous Technical Knowledge (ITK) plays an irreplaceable role in forest conservation and natural resource management. The deep-rooted wisdom of communities like the Toda and Soliga tribes offers sustainable solutions that have stood the test of time. As modern challenges like climate change and ecosystem degradation intensify, there is a growing need to recognize, revive, and integrate ITK with contemporary approaches. By fostering collaborations between indigenous communities and government agencies, it is possible to blend traditional practices with modern science, creating holistic conservation strategies. This not only ensures the protection of natural resources but also preserves cultural heritage for future generations, guiding us toward a more sustainable and ecologically balanced future.

References

Sasanka Lenka1 and Abhijeet Satpathy. “A Study on Indigenous Technical Knowledge of Tribal Farmers in Agriculture and Livestock Sectors of Koraput District”, Indian Journal of Extension Education, Vol. 56, No. 2 April-June, (2020): 66-69.

Sahely Kanthal1 and Suman Garai. “Identification of Different Indigenous Technical Knowledge Application in Agriculture and Allied Sector in Some Selected Areas of West Bengal”, Journal of Survey in Fisheries Sciences 10(1S), (2023):7022-7025.

Arun Somagond, B. H. M. Patel, Bosco Jose, Pranay K. Kumar, Seema Yadav and Pramod Kumar Soni. “Role of Livestock in Sustainable Living for Soliga tribe in B R Hills of Karnataka”. International Journal of Livestock Research, Vol. 10 (6), (2020).

Sandhya Shenoy. N. “Indigenous Technical Knowledge and its relevance for Sustainability”. 105th FOCARS Digital repository, (2019), National Academy for Agriculture Research Management, NAARM, Hyderabad.

Ramasubramanian. R. Tribal Culture in Nilgiris. Think India Journal, Vol – 22, Issue 10 – November – 2019.

Logesh and Gangadhar. An Economic Empowerment of Soliga Tribe in Chamarajanagara District, Karnataka. Juni Khyat, Vol-13, Issue-05, No.01, May, 2023.

Volume: 04 Issue No: 12

ROLE OF SOCIAL AND SOLITARY BEES FOR CROP POLLINATION SERVICE UNDER PROTECTED CULTIVATION

Article ID: AG-VO4-I12-43

***S. Sheeba Joyce Roseleen[1], V.K.Satya[2], A. Nithya Devi[3], K. Kumanan[4], S.Malalthi[5] and P.Yasodha[6]**

[1,2,6,] Horticultural college and Research Institute for Women, Tiruchirappalli , 620 027

[4] Agricultural College and Research Institute, Kudimiyanamalai

[3]Dr. M. S. Swaminathan Agrl. Coll. & Res. Inst., Eachangkottai, Thanjavur, 614 902,

[5]Information and Training Centre, TNAU, Chennai, 600 032

*Corresponding Author Email ID: sheeba@tnau.ac.in

Introduction

Pollination is a fundamental ecological process that is essential for the reproduction of the vast majority of flowering plants, or angiosperms, which make up a significant portion of the world's flora. Around 75% of these plants, including both wild and cultivated species, are either fully or partially dependent on insect pollination to complete their reproductive cycle. This means that the survival, genetic diversity, and propagation of these plants rely heavily on the services provided by insect pollinators. Given that plants form the base of most ecosystems, it is not an overstatement to say that the sustenance of humankind and indeed most life on Earth is intricately linked to the activities of pollinators.

Among the most effective pollinators are bees, a diverse group of insects that includes over 20,000 identified species worldwide. While the honeybee (*Apis spp*.) is perhaps the most well-known and widely recognized bee due to its social structure and human domestication for honey production, the reality is that most bee species are not social. In fact, about 85% of bee species are solitary, meaning that each female bee lives and operates independently rather than in a cooperative colony structure like honeybees. These solitary bees may not be as efficient in large-scale pollination efforts compared to their social counterparts, but their ecological importance is undeniable. They contribute to pollinating a wide range of plants, many of which are vital for the production of fruits, vegetables, and other crops crucial to human diets and economies.

The relationship between bees and plants is a result of millions of years of co-evolution. Plants have evolved specific traits to attract pollinators bright colors, attractive scents, and the production of nectar and pollen as rewards while bees have developed specialized behaviours and physical adaptations to optimize their foraging. This symbiotic relationship is one of nature's most delicate and efficient systems, ensuring the proliferation of plant species through seed production while providing bees with the sustenance they need to survive and reproduce.

However, not all bees contribute to pollination in the same way. Social bees like honeybees and bumblebees are often regarded as the most efficient pollinators due to their large colonies, division of labour, and capacity to pollinate vast areas. But solitary bees, which often resemble wasps rather than traditional bees, play a vital, albeit often overlooked, role in this process. Each solitary bee female mates, forages, and nests independently. They build their nests in various substrates like dry soil, hollow plant stems, or dead wood logs, often creating a series of brood cells. Inside these cells, the female stores pollen and nectar for her larvae (a process known as mass provisioning) before sealing them off to allow the next generation to develop.

In recent years, the population of solitary bees, like many other pollinators, has been declining at an alarming rate. This decline is largely due to anthropogenic factors such as habitat destruction, pesticide use, and climate change, which disrupt the natural environments these bees depend on. Unlike social bees that can adapt more easily to environmental changes, solitary bees are more vulnerable due to their specific nesting and foraging needs. The loss of suitable nesting sites has become a significant limiting factor for their survival, leading to a cascading effect on the plants that rely on them for pollination.

In response to this crisis, some farmers and conservationists are taking proactive measures to support solitary bees. They are creating artificial nesting habitats such as bee hotels and managed field margins to provide suitable conditions for these pollinators. This is particularly important in areas where honeybee populations are insufficient to meet pollination needs, such as in certain horticultural crops. In many regions, farmers are increasingly aware of the pollination services provided by solitary bees and are encouraging their presence as part of a broader strategy to enhance crop yields and biodiversity.

Major Solitary Bees Solitary Bees are mainly residing among the nine families of order Hymenoptera,

1. Colleitdae - Membrane bees
2. Andrenidae - Digger bees
3. Halticidae - Sweat bees
4. Megachilidae - Leaf cutter and Mason bees
5. Anthophoridae - Carpenter and Minor bees
6. Meltittidae- Meltittid bees
7. Oxaeidae - Ground nesting bees
8. Fiedellidae – hopper bees
9. Apidae / Honey bees, Stingless bees, Orchid bees and Bumble bees

In Protected cultivation

In India, where agriculture plays a central role in food security and economic growth, the importance of pollination, especially in horticulture, is growing. The country’s diverse agro-climatic conditions allow for the cultivation of a wide range of crops, including fruits, vegetables, and flowers, many of which rely on insect pollination. As horticulture continues to expand, particularly with the rise of protected cultivation practices like greenhouses, ensuring adequate pollination becomes even more critical. Protected cultivation, which allows farmers to control environmental factors such as temperature, moisture, and light, offers numerous advantages, including the ability to grow high-quality vegetables in off-seasons. However, it also presents challenges, including the need for effective pollinators in enclosed environments where natural pollination by wind or wild insects may be limited.

Globally, pollinators, especially bees, are vital not only for agriculture but also for maintaining the health and stability of ecosystems. The interdependence between plants and their pollinators exemplifies the intricate balance of nature, where the decline of one can have far-reaching consequences for the other. With an increasing awareness of the importance of pollination and the threats facing pollinators, efforts to protect and support both social and solitary bee species are essential for the future of food production and biodiversity conservation.

Thus, there are diverse types of bees, forming large groups that are quite distinctive in size, tongue length and behaviour; thus, generalization about bees is not easy. Some plants can only be pollinated by bees because their anthers release pollen internally, and these must be shaken out by buzz pollination. Bees are the only animals that can help accomplishing this, e.g. bumblebees that sonicate, but honeybees do not. One of the limitations for crop cultivation under cover/greenhouse is insufficient pollination due to the protected structure of the greenhouse which keeps the pollinators at bay, and that may result in low yield and quality of the produce. Thus, pollination agents are required for a high quality fruit and seed set. Insufficient pollination causes low 206 pollen supply which also affects the progeny vigor by reducing the selectivity among the gametes before and during fertilization. Managed bee pollination or planned bee pollination or pollination management implies management of pollinators (bees) to enhance crop pollination. According to Ombir and Kumar, 80 per cent of flowering plants, 90 per cent of all horticultural and vegetables crops especially hybrids depend upon insect pollination. Pollinators are extremely diverse, with more than 20,000 bee species and other numerous insects and vertebrate pollinators.

To overcome the pollination deficit, various no pollinator strategies are employed. First one would involve meeting the pollination requirement through physical means i.e. manual pollination by involvement of human force. But it is laborious, time consuming, lose selectivity vigour and of course a costly affair. The other option would be having self pollinated crops, and finally the ones that would bear fruit and produce seed without pollination, i.e. the cultivation of parthenocarpic cultivars. Cucumbers being grown under protected cultivation are generally parthenocarpic ones. But the other best option is employing the agent which provide pollination service exercising selectivity to provide the desired vigour and the process is not laborious and economical. The agent is a small creature – the bee. The managed bee pollination will involve various strategies including the choice of the bee species, number of bees per unit area, placement of bees under the cover, increasing proportion of pollen gatherers, etc. Bees are more efficient pollinators than other insects as their body is hairy to facilitate in carrying the pollen and collect the pollen methodically. But honey bees are more reliable as they can be managed in any number, at any place and at any time. Further, they have floral constancy and floral fidelity behaviours, and they collect the pollen as food and also provide honey.

Pollination by Sollitary bees in protected cultivation

TAXONOMY

Honey bees belonging to family Apidae, subfamily Apinae, including Tribesapini, Bombini and Meliponini which are social ones living in colonies. Apis bees generally have large colonies and have long flight range, except *Apis florae* Fabricius. The 207 larger colonies with bees with longer flight range and those that have voracious resource requirements do not fit into the category of using under protected cultivation, as under the cover, the plant population will be lesser to support the colony and further the long flight range of bees will make the bees to keep them darting into walls of the covers and dying there. *A. florea* is a wild honey bee species which though has shorter flights but still are longer when considering the cover size, and moreover on disturbance, these may sting even though that may be less painful. They require warmer climatic conditions. In bigger cages where they will not encounter any disturbance, may be a candidate bee species that will provide some honey as well. Among other Apids, *Apis mellifera* Linnaeus could be another candidate for extra large covers but the colony size has to be small enough i.e. not more than 2 bee-frames, and sugar feed has to be given to meet the colony need.

SPECIES OF BEES

Bombus species (bombini) are bees of the temperate areas that maintain annual and small colonies and have low flight range and less resource thrifty. In western countries, particularly in Europe, *Bombus terrestris* (Linnaeus) is the most widely used species for pollination under protected cultivation. In Indian plains, bumblebees are seldom found and cannot be utilized there for high temperature is not suited to its colonization. In Indian temperate areas, particularly in north, *Bombus haemorrhoidalis* Smith is the common found species and their mass rearing has been standardized; however, its release or its availability to the grower is to be ensured. The colony may vanish during extreme winter and may need its purchase afresh after the onset of spring. *Meliponis* could be the candidate species in the other areas than temperate. Seven species of *Tetragonula* (Makkar et al., 2016) have been reported from India. *Tetragonula iridipennis* Smith is the commonest and widespread in the plains. This bee makes small colonies and has low flight range chiefly upto 50 m and is polylectic and being very small in size, it can easily enter into narrow corolla tube. It is also less resource thrifty. Its honey is also considered exquisite and fetches premium price. Its rearing and hiving technologies have also been standardized. It is a potential candidate for pollination under protected conditions.

POLLINATION EFFICIENCY IN VARIOUS CROPS

At the global level, many species of bombids and meloponids, and also apids have been evaluated for their pollination efficiency of various crops under protected cultivation and the cues the bees respond to in the crops have been found out. Further, studies have been conducted on the effectiveness of the employment of the bees on the quantity of and quality of the produce. Conservation and augmentation efforts of some solitary bees like small carpenter bee/ metallic bee, *Pithitissmarg dula* and large carpenter bee, *Xylocopa pubescens* & *Xylocopa fenestrata* that can be kept on varying diameters of bamboos, are other candidates for the crops grown under the cover. On tomato, Ahmad et al (2015) evaluated *B. terrestris*; Strange (2015) compared the effectiveness of Bombushuntii Greene, *Bombus impatiens* Cresson and B. vosnesenskii Radoszkowski. Hikawa and Miyanaga (2009) compared the pollination efficiency of *Melipona quadrifasciata* and *B. terrestris*. When the amount of tomato pollen was sufficient, there were no differences in pollination efficiency between the stingless bee and the bumblebee; however, the rates of foraged flowers, the rate of fruit set and the yields were significantly reduced in the stingless bee compared with the bumblebee when fertile tomato pollen decreased markedly during the hottest period of the summer. In summer, the rate of flowers foraged by bumblebees did not decrease, but the rates of fruit set, the seed number and the yields of tomato fruits decreased as the pollen production was inhibited at high temperatures. Under such situations, the stingless bee was more effective. Bartelli and Ferreira (2014) reported *M. quadrifasciata* to be effective for the pollination of grape tomato. The tomatoes originating from flowers visited by *M. quadrifasciata* produced about 47 per cent more seeds and their concentration of sugar was approximately 14 per cent higher. Putra and Kinasih (2014) reported the efficiency of *Apis cerana* Fabricius and *T. iridipennis*. Pollination efficiency of *A.cerana* was 10 percent higher than *T. iridipennis. A. cerana* and *T. iridipennis* resulted in 8 and 6 per cent increase in total fruit production per plant over the control.

EFFECT OF FLORAL VOLATILES ON BUMBLE BEES

Andrew *et al.* (2012) reported the effect of the floral volatiles on bumble bee (B. impatiens). This study investigated 209 flower characteristics and their effect on bumble bee pollination by a) observing foraging preferences for bumble bees on greenhouse tomato, b) determining if the plant on floral advertisements could be used by the bees to estimate pollen availability, and c) identifying temporal changes in floral display which correspond to peak bumble bee activity. The results indicated that a) bumble bees preferred to pollinate flowers which produce less phellandrene and 2-carene in comparison to flowers producing more of these volatiles,b) flower size and floral scent were not likely to be used by the bees to estimate pollen availability, and c) cultivars are inconsistent in their production of floral volatiles during peak bumble bee activity phellandrene and 2-carene may be antiherbivory volatiles and reduced production during peak bee activity to protect flowers from damage caused by over-pollination.

EFFECTIVENESS OF BEES AS POLLINATORS IN GREEN HOUSE

In the case of cucumber, Santos and Bego (2008) investigated the effectiveness of the stingless bees *Scaptotrigon aaff. depilis* Moure and *Nannotrigona testaceicornis* Lepeletier as pollinators of cucumber plants (*Cucumus sativus var. caipira*) in greenhouses during the Brazilian winter season. The highest cucumber yield (with the highest amount of perfect fruits) was found in those greenhouses which housed the stingless bees as pollinators (GH I, GH II). Stingless bees increased the number of fruits 20 and 78 per cent over open pollination and without bees, respectively. In India, Kumar and Ombir (2016) reported *A. mellifera* pollination in cucumber under polyhouse. *Apis mellifera* colony was introduced in polyhouse for pollination of cucumber. *A. mellifera* commenced its activity early in the morning at 0700 h and attained its peak activity and maximum abundance on cucumber during 0900-1000 h. Significant increase in visiting frequency of honeybees was observed at the time of full bloom and again the abundance decreased significantly at the time of cessation of the flowering. In bee pollination, fruit setting percentage, fruit length and fruit weight were close to bee + hand pollination which increased the income by reducing labour cost. Sweet pepper is another vegetable commonly being grown under polyhouse conditions.

Dag and Kammer (2011) reported that honey bee (*A. mellifera*) and bumble bee *(B. terrestris*) both were effective.The yield was 30 and 36 per cent 210 higher in case of honey bee and in bumble bee, respectively over control, and also grade A fruit were 32 per cent higher in case of both the bees over control. Cruz et al. (2005) carried out study in Northeastern Region of Brazil, to investigate the use of stingless bee *Melipona subnitida* Ducke in the pollination of greenhouse sweet pepper (*Capsicum annum* L.). Treatments of hand crosspollination, hand self-pollination, pollination by bees and restricted pollination were performed. Results showed that despite sweet pepper flowers are considered autogamous, this crop benefitted from bee pollination, producing fruits significantly heavier and wider, containing a greater number of seeds and of better quality (lower percentage of malformed fruits) than self-pollinated sweet pepper. It resulted in significant increase in number of fruit i.e. 12 and 52 per cent over self-pollination and over hand self-pollination. Chilli, another vegetable also grown under polyhouse conditions, was also under investigation by various scientists to observe impact of bee pollination and to find a candidate bee best suited for the purpose. Azmi et al. (2016) investigated the pollination efficiency of stingless bee (*Heterotrigona itama*) on Chili (*Capsicum* *annum*) in Malaysia.Chilies produced from pollination by *H. itama* and hand-cross pollination were significantly heavier, longer and containing greater number of seeds per fruit than self-pollinated chilies. This occured because *H. itama* deposited a great number of viable, compatible pollen.In contrast, hand-cross pollination needs a lot of precision and requires skilled workers in order to produce high quality progeny. Failure to do so may probably lead to high number of malformed fruits. Chandel et al. (2015) reported the effect of size of net house on performance of *A. mellifera* in pollinating cabbage. No formation of siliquawas observed in plants raised in the net house of dimensions of 3 x 2 x 2.25 m than when raised in net house of 15 x 7 x 4.5 m. A study on strawberry by Paydas et al. (2001) reported the effect of pollination by bumble bees and honey bees on different cultivars of the crop.

Honey bee and bumble bee significantly increased yield of all strawberry cultivars and improved their quality by improving TSS and acidity. 211 In fact, regional bee fauna is required to be evaluated for their use as candidate pollinator, on case by case basis for the various crops under protected cultivation. There is need to ensure their availability and management. Further, the effectiveness may also be a factor of the prevailing environmental conditions under the cover that may be different for different types of covers and the environmental conditions for the crop. Even in the case of self pollinated crops, the bees in open conditions as well as under cover have resulted in supplementary yield and quality. Use the bees as your robotic labour to get you bountiful harvest. Their conservation and augmentative measures while would provide handsome reaps, the efforts will also usher in rewards of ensuring biodiversity.

Conclusion

Both social and solitary bees play crucial roles in enhancing pollination within protected house crop production. While social bees, such as honeybees and bumblebees, are often the preferred pollinators due to their social behaviours and ability to work in large colonies, solitary bees offer unique advantages, particularly in complementing pollination where social bees may fall short. The diversity of bee species ensures a more resilient and effective pollination system, contributing to higher crop yields and improved quality in controlled environments likes greenhouses. As protected cultivation continues to grow in importance, integrating both social and solitary bees into these systems can optimize pollination efficiency, promoting sustainable agricultural practices and boosting food security. It is essential to create and maintain suitable habitats for these pollinators, ensuring their survival and enhancing their vital ecological contributions to crop production.

References

Balakumar, R., and Egambaram, S. (2020). Solitary Bees -Alternative and silent crop pollinators. *ResearchGate*. https://www.researchgate.net/publication/350344650

Birmingham, A.L. and Winston, M.L. (2004). Orientation and drifting behaviour of bumblebees (Hymenoptera: Apidae) in commercial tomato greenhouses. Can. J. Zool., 82: 52-59.

Dyer, A.G. and Chital, L. (2004). Bumblebee search time without ultraviolet light. J. Exp. Biol., 207: 1683-1688.

Goodman, L. (2003). Form and function in the honey bee. IBRA, Cardiff, UK, 220 pp.

Kumar, S., Patel, N. B., Saravaiya, S., and Patel, B. N. (2018). Technologies and Sustainability of Protected Cultivation for Hi-Valued Vegetable Crops. *ResearchGate*. https://www.researchgate.net/publication/326016018

Volume: 04 Issue No: 12

AGRO PROCESSING AT FARM LEVEL: FOR EMPLOYMENT AND INCOME

Article ID: AG-VO4-I12-44

***Raj Kumar[1] and Gurpreet Kaur[2]**

[1] Principal Extension Scientist (Agricultural Economics)

[2] Principal Extension Scientist (Agricultural Economics)

Department of Economics and Sociology, PAU, Ludhiana, India

*Corresponding Author Email ID: rajkumar@pau.edu

Introduction

Value addition via agro processing at the production catchment itself is a tactic that can raise the farmers' income and employment opportunities. Along with creating employment in rural areas, agro processing can also help in lowering post-harvest losses of agri produce. A study by NABARD Consultancy Service Pvt. Ltd. (2022) estimated the average post harvest losses to the tune of 4.87-11.61% in vegetables, 6-15% in fruits, 3.9-5.9% in cereals, 5.6-6.7% in pulses and 2.9-7.5% in oil seeds. In order to prepare, preserve, and consume perishable farm produce throughout time, it is crucial to add value to raw agricultural produce through agro processing which needs infrastructure, capital, technology, and expertise. Agro processing is a technique by which suitable products are produced from farm produce as per demand of the consumers.

In the present scenario, the produce is procured by the public agencies or private traders in the *mandis* from which various products are manufactured in the agro industries. After adding the profit margin of various intermediaries like wholesalers, dealers, retailers, etc. the products are made available to the consumers at exorbitant prices. The farmer's share in the price paid by the consumer remains very small. In such a way, both the producer and the consumer of the product suffer. Among farmers and extension workers alike, there is a dearth of knowledge regarding the agro processing. A robust and active agro processing at farm level is essential to the commercialization and diversification of agriculture. Small farmers would undoubtedly benefit as it will enable them to generate income sources other than the sale of raw produce.

To reap the full benefits from the farming, it will be beneficial to sell the produce after processing and proper packing. Initially farmers can clean and pack their produce at their own level and then sell it directly to the consumers. For example, making flour from wheat, proper packing of corn maize, chickpeas, *moong*, etc. can earn 15-20 per cent more than selling the raw produce in the market. The oil of canola mustard variety GSC 7 can fetch higher price than ordinary mustard oil. Making *vesan* from chickpeas, salted *dal* from mung bean, milk/cheese from soyabean, jaggery/*shakkar*/*gachak* from sugarcane, etc. can also be a good choice.

Similarly, selling of turmeric powder instead of raw turmeric nodes can fetch a price of about Rs. 150-200 per kg. The PAU has developed some machines for turmeric processing. The turmeric washing and polishing machine costs about Rs. one lakh and requires one HP motor. The turmeric boiling machine can be run by using crop residue and has a average capacity of 10-12 quintals per hour. It costs about Rs 5-6 lakh which can also be custom hired at a rent of about Rs. 5,000 per day to process the produce. However, commercial boiling pan, usually used in sugarcane juice boiling for making jaggery, can also be used for this purpose which costs about Rs. 3 lakh. Solar dryer and turmeric grinding machine are also available for drying turmeric. The turmeric washing and polishing machine costs about Rs. one lakh and requires one HP motor. Tomatoes can be sold in the form of ketchup and puree after processing. Green peas can be stored at low temperature during its peak season and can be sold later at higher prices. Mushrooms can be sold in the form of pickle and dried powder. Honey may be marketed by packing it in small bottles for better earnings rather than to sell it in large tins at lesser prices. Some other options are; bottling of ready to consume sugarcane juice, preparation of value-added jaggery cubes/bars, installing mini groundnut decorticator-cum-sunflower thresher and maize sheller, installing multipurpose grain mill for grinding cereals/pulses/spices to produce flour/grits/powder/split; and the honey processing unit for the small entrepreneurs to process honey in the production catchment itself.

Set up of Agro Processing Complex

The agro processing complexes in rural areas need to be developed to generate employment and income for the rural youth. About 300 such APCs have already been running in the state successfully and more number of such units needs to be installed. These can be set up individually or jointly by a group (SHG/FPO) which will help in cost sharing and marketing of the products and there will be more number of working hands. For processing at farm/village level, APCs may be started with two or more machines like mini rice mill, baby oil expeller, flour mill, grinder, pulse cleaner-cum-grader and feed mill. The financial assistance can be sought from government banks, *Khadi* and Village Industries Commission, Ministry of Food Processing Industries, etc. These institutes provide 25% subsidy to the farmers and 30% to the farm women for setting up such units. For border areas or backward areas, facilities like electricity connection on priority basis, tax exemption and reduction in interest rates on loans, etc. are also provided.

Income from agro-processing complex

A flour mill, oil expeller and grinder can be run smoothly with the help of only one helper. After meeting all expenses, one can earn up to Rs. 30-40 thousand per month. The net returns from the entire agro-processing complex may be between Rs. 50,000 and Rs. 1,25,000 per month depending upon the managerial efficiency.

Investment required for agro-processing complex at farm level

Item	Capacity (Quintal/hour)	Approx. Cost (Rs.)
Mini rice mill (with two polisher elevators and graders)	2.50	3,70,000
Baby oil expeller (with filter press)	1.00	5,00,000
Flour mill (with scourer)	5.00	7,00,000
Flour mill (Rajasthani)	1.50	50,000
Grinder	0.50	70,000
Pulses cleaner and grader	1.00	60,000
Animal feed mill (grinder & mixture)	9.00	3,50,000
Electric motors (about 4)	Varying capacity	1,50,000
Total investment	**-**	**22,50,000**

Note: An additional cost for construction of shed about Rs. 20-25 lakh on about 3000 sq ft area

To make the processed products trustworthy among consumers, these should get certified from AGMARK/FASSI. To boost the sale of products, the regular contact with wholesalers/retailers in the cities for bulk orders is also desirable. They can also sell their produce at *Kisan Melas*, farmers' training camps, etc. The 'ATMA Huts' set up by the Department of Agriculture and Farmers' Welfare in almost each district as well as '*Apni Mandi*' can also be of great help for the sale of processed produce. For basic knowledge and training, *Krishi Vigyan Kendras* (KVKs) of PAU may be visited. For the advanced training, the Department of Processing and Food Engineering, PAU, Ludhiana may be consulted.

Volume: 04 Issue No: 12

MODERN AGRICULTURE TECHNOLOGIES IN MARIGOLD CULTIVATION FOR SUSTAINED ECONOMIC RETURNS FOR SMALL AND MARGINAL FARM WOMEN

Article ID: AG-VO4-I12-45

Dr Rekha Tiwari [1], Ghazala Khan[2] and Dr D S Tomar [3*]

1,3 Senior Scientist: 2 Senior Technical Officer

Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior (M.P), India

Corresponding Author Email ID:* tomardivakar66@gmail.com

Introduction

Agriculture of our nation is witnessing a continuous change particularly in the cropping and land use system. The trend of last few decades shows diversification from field crops towards horticultural crops particularly floriculture in peri urban and areas designated for high demand of flowers round the year such has holy places and large towns coupled with a steady increase in demand of flowers on account of increase in per capita income and change in life-styles. By taking all this into consideration Government of India has accorded floriculture a fully export-oriented status and has also recognized it as industry of the future. Due to enhanced demand of the loose flower, bouquet, garland and wreath, the cultivation of flowers now-a-days is a prospective enterprise in Indian economy. With the grand celebration of progressive 75 years of countries progress after independence as 'Azaadi Ka Amrit Mahotsav' and various studies and schemes envisage upon women as "Empowered women for Empowered Nation". Women are extensively engaged in the activities pertaining to agriculture and allied sector. The workforce participation rate for rural females is significantly higher at 41.8 percent against urban women participation rate of 35.31 percent (*Ministry of Statistics and Programme Implementation ,2017*). The growth in agricultural in the country has been associated with an increase in female employment, a process that is often claimed to enhance women's empowerment. However, empowerment is a contested concept and several studies have highlighted that far from empowering workers, employment can often be precarious, exploitative and harmful.

Madhya Pradesh is the second largest state and ranks seventh in population, surrounded by the states of Rajasthan to the northwest, Uttar Pradesh to the north, Chhattisgarh to the east and Maharashtra to the south, and Gujarat to the west. The State is primarily an agriculture State with 73 per cent population residing in rural area and hence the primary occupation is agriculture. Agriculture and allied services contribute about 44 per cent share in state economy and 78 per cent of its working force is directly engaged in agriculture. In recent years, greater emphasis has been given to horticultural sector and at present state is producing about 38.15 MMT of horticulture produce from an area of 2.57 M ha and accounts for 3.2 per cent of total horticulture produce of the country. The major share of horticulture produce is from vegetables (48.1%), fruits (43.8%) and only 8.1 per cent from flowers. Flower cultivation in peri urban areas accounts to 9.16 M ha with total production of 7.14 MT and a poor productivity of mere 0.78 MT per ha, (*Department of Horticulture and food processing 2023-24*).

Over the years women's access to land, livestock, education, financial services, extension, technology has increased many folds has led to rural employment enhance their productivity and self-esteem leading to quality agricultural production, food security, and economic growth. Achieving gender equality and empowering women in agriculture is not only the right thing to do. It is also crucial for agricultural development and food security. (FAO, 2011). Today the biggest challenge before the thinktanks is to enable the women force with modern technologies and encourage them to be entrepreneurs in most lucrative flower industry.

Drivers of Change:

Krishi Vigyan Kendra spread across the countries through their mandates such as Technology Assessment, Refinement and Demonstration and introduction of new Technologies and Products have made an impact of the socio-economic status of women. The present case corresponds to the grass root level effort of Krishi Vigyan Kendra Ujjain over the last one decade in flower cultivation through small and marginal women farmers who could exclusively devote their time, energy and land for the cultivation of flowers particularly the marigold which has round the year demand in the holy city of Ujjain for garland and decorative purposes at various kinds of religious and social functions.

Cultivation of Marigold:

Marigold flowers are native to North and South America however, the first garden plants introduced into Europe came from Northern Africa. The African marigold is native to Mexico and other American tropics, where about 50 species occur whereas the French marigold is native to Mexico, Nicaragua and Guatemala (South America). The major producers of *Tagetes erecta* are Mexico, Peru, Ecuador, Argentina and Venezuela while the minor producers are India (Kolkata region), South Africa and Zambia. The leading countries in producing marigold flowers are China, India, and Peru while the major marigold flowers importing countries include the United State of America and Europe. The production level of marigold flower in these countries is not well documented. It has become popular among vendors, gardeners and dealers for its simple cultivation and wide versatility besides being more profitable than tradition crop to the farmers. Marigold finds its use in medicine, perfume industries and owing to the presence of natural carotenoid pigment has a wide use in poultry feeds. In addition to commercial production for loose flower purpose, it has several other uses.

The essential oil from *Tagetes erecta* flowers has been used in high class perfumery and also acts as anti-haemorrhagic, anti-inflammatory, antiseptic, antispasmodic, astringent, diaphoretic and emmenagogue. The oil is very valuable in aromatherapy for its powerful skin healing effects and also possesses fly repellent properties. Marigold varieties have pesticidal value as they destroy ground pests particularly nematodes. The genus is also recognized as a potential source of very interesting biologically active products viz. carotenoids that are currently being used as food colorants, nutritional supplements and poultry feed additives and in ophthalmology for the treatment of age-related ocular diseases viz. cataract and dry age-related macular degeneration (ARMD).

Table 1: Area and Production of major flowers and in Madhya Pradesh

Name Flower	Area (Ha)		Production (tons)		Productivity tons / ha
	2020-21	2021-22	2020-21	2021-22	
Marigold	20736.3	21183.4	270797	276931	13.07
Rose	3608.01	3844.77	33069	34800.2	9.10
Chrysanthemum	1492.95	1573.85	19375.6	20468.9	12.99
Tuberose	244.23	234.98	2896.36	2563.83	11.39
Gladiolus	941.07	1015.92	7880.15	8408.77	8.32
Others	8705.64	9794.7	78712.6	83447.1	8.76
Total	**35728.2**	**37647.5**	**412730**	**426620**	**11.43**

Source- Department of Horticulture and Food Processing, Madhya Pradesh, 2022

Technologies Adopted and Identified for Future Through Package of Practices

Soil and Environment: Marigold is cultivated in most parts of Madhya Pradesh and has the largest area among flower crops. It is one of the easiest annual flowers to cultivate, having wide adaptability. They produce marketable flower in a short period of time. This can be grown in a wide variety of soil but well drained, fertile sandy loam soil, pH 7.0–7.5 is preferable. It requires mild climate for healthy growth and flowering. Temperature of 15-27 ^{0}C is generally preferred. Marigold can be raised three times a year- rainy, winter and summer seasons and is commercially propagated by seeds

Improved varieties:

Pusa Narangi *Gainda* (orange-coloured flowers) and Pusa Basanthi *Gainda* (sulphur-coloured flowers), two important high yielding varieties from IARI, New Delhi developed in the year 1995 have revolutionized marigold production in the country. Since then, there is a long gap of around 20 years for the development of more improved varieties in African marigold.

Arka Bangara - 2, Arka Agni and Arka Bangara from IIHR, Bengaluru were developed and released during 2014-15. These are also high yielding with better flower quality. Improved varieties in French marigold include Pusa Arpita (IARI 2009), Pusa Deep (IARI 2018), Arka Honey and Arka Pari (IIHR 2018-19).

Seed Propagation for Seedlings:

To get healthy, vigorous, insect and disease-free seedlings the women farmers were given pro-trays along with growing media. The pro-trays were then kept in partial shade or in low tunnel poly houses for germination, providing all the foliar nutrients and pesticides on need based requirements. Most of the recent varieties are propagated through vegetative means (terminal rooted cuttings). Healthy seedlings should be transplanted at 3 to 4 leaf stage. Pre-emergence application of weedicides pendimethalin 1.25 – 1.50 litre per hectare) and use of drip irrigation system – one drip line for every two rows of the crop planted on raised or flat beds were found to be enhancing the crop growth and flowering significantly.

Pinching of Terminal Buds and use of Gibberellic acid:

Quality of flower has great value in case of marketing of cut flowers, so varietal performances have gotten value for deciding the planting of single variety. Similarly, pinching is one of the most important cultural operations in marigold cultivation. Pinching has direct relationship with number of flowers and regulation of flowering for successful marketing. Pinching delays the flowering time and increase number of branches per plant which directly increase yield by slashing the effect of apical dominance. Pinching reduces flower size which is helpful in reducing the calyx splitting due to reduce number of petals in flower. Plant growth regulators are mainly used for the regulation of plant growth and development by modifying various physiological processes of the plant. The impact of stressful conditions like drought mainly due to high temperature during the early growing season can be minimized by the treatment of plants with growth regulators

Table.2 Impact of Pinching and GA3 application on Marigold on farmer's field.

(Pooled data 05 Years):

Pinching	Plant Height Cm	Branches per plant	Flowers per plant	Yield qt per hectare	Vase Life days
No Pinching	63.5	11.3	26	82.2	4.5
30 DAT	49.7	17.5	32	134.6	5.7
45 DAS	45.2	21.6	36	141.3	6.4
Mean of treatment	47.45	19.55	34	137.95	6.05

% Increase over control	-25.3	73.0	30.8	67.8	34.4
GA3 Spray					
No Spray	62.4	10.2	24	80.6	4.2
150 ppm	46.2	18.1	34	129.7	5.5
250 ppm	44.8	20.8	39	137.4	6.1
Mean of treatment	45.5	19.45	36.5	133.55	5.8
% Increase over control	-27.1	90.7	52.1	65.7	38.1

Phenophase based irrigation and fertigation:

Method of nutrient application to plants is also a key issue to get the optimum potential of the crop. Fertigation helps in reducing the wastage of nutrients through enhanced use efficiency of fertilizer besides providing flexibility in timing of fertilizer application in relation to crop demand based on phenological stages of growth It also determines quantity of nutrients, timing of application and most important component of water distribution. The amount of nutrient and water requirement of a plant varies according to its Phenophase and dispensation of water and nutrients can be scheduled accordingly. The fertigation scheduling should be based on plant, soil-air, plant water relations and growth stage of plant. Research communications suggests that in the vegetative phase of Marigold, the irrigation at vegetative, bud and flowering in combination with fertigation treatment 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase) 30:40:40% NPK (flowering phase) @ 75:112.5:75 kg NPK/ha was found adequate to cater the demand of water as well as nutrient requirement for vegetative phase of chrysanthemum var. Marigold.

The above simple interventions make a huge change in the perception of farmers, as these technologies are not only affordable but also rewarding. But the future of agriculture is technology driven, hence the below mentioned technologies will not only increase the production but also enhance the financial many folds. But, the policy of the government needs to be farmer centric and pro-poor because the small and marginal women farmers would not be able to afford. Hence, large scale subsidies need to be pooled in this sector by inviting the private investments.

IoT in Flower Cultivation: Future Technologies at the door steps:

Kevin Ashton coined the word "IOT" in 1999. It stands for "internet of things," which refers to the connection of everything to the internet and the relationship between people, things, and people. The network of physical items, or "things," embedded with electronics, software, sensors, and network connectivity that allows these objects to gather and share data is known as the Internet of Things (IOT). " Internet changed the world, similarly Internet of Things [IOT] would do in the coming days or decade. The role of the Internet of Things (IoT) in flower cultivation is growing rapidly, offering ways to improve the quality, yield, and sustainability of flower production. IoT technologies enable flower farmers to monitor and optimize growing conditions, reduce resource consumption, and enhance automation. Below is a detailed look at how IoT is impacting flower cultivation.

1. Smart Greenhouses for Controlled Flower Cultivation

-IoT-enabled greenhouses are equipped with sensors that monitor and regulate environmental factors like temperature, humidity, light intensity, and soil moisture. By providing precise control, IoT helps maintain optimal growing conditions for flowers, which are often sensitive to environmental changes.

- Example: Sensors inside a greenhouse can measure humidity levels and automatically adjust misting systems to maintain the right moisture, ensuring healthier growth and more vibrant blooms.

2. Automated Irrigation Systems

IoT-based smart irrigation systems can automate watering schedules based on real-time data collected from soil moisture sensors. This ensures that flowers receive the exact amount of water needed, reducing water waste and preventing over-irrigation.

Example: A soil moisture sensor in a flowerbed detects when the soil is dry and automatically activates the irrigation system, watering only when needed.

3. Monitoring Soil Conditions

IoT devices help monitor critical soil parameters such as pH, nutrient levels, and moisture content. By analysing soil conditions, farmers can optimize fertilization schedules and avoid nutrient imbalances, leading to healthier and more robust flower growth.

Example: Sensors can alert farmers if the pH level of the soil is too acidic or alkaline, allowing them to adjust fertilization practices accordingly.

4. Climate Control and Lighting Automation

-Many flowers require specific lighting and temperature conditions to grow and bloom effectively. IoT systems can automate climate control in greenhouses, adjusting heating, ventilation, and lighting based on real-time environmental data.

Example: IoT-controlled lights can simulate day and night cycles or adjust light intensity based on the flower type's needs, promoting optimal growth and flowering.

5. Pest and Disease Monitoring

IoT sensors and cameras can detect the early signs of pests and diseases in flower crops. With automated alerts, farmers can take timely action, preventing the spread of infestations and reducing the need for harmful pesticides.

Example: IoT cameras equipped with AI can identify small insects on flowers and send alerts to the farmer, enabling early intervention before the infestation becomes widespread.

6. Drones for Aerial Monitoring

Drones equipped with IoT sensors can fly over flower fields or greenhouses to collect data on plant health, growth patterns, and irrigation needs. They provide real-time aerial views and thermal imaging to help identify areas that need attention.

- Example: A drone flying over a flower farm captures high-resolution images and uses thermal imaging to detect areas of heat stress or water deficiency, allowing for quick intervention.

7. Automated Fertilization

- IoT systems can automatically manage fertilizer application based on the real-time needs of the flowers. By using data from soil sensors and weather forecasts, farmers can deliver nutrients precisely when and where they are needed.

- Example: Sensors detect that nutrient levels in a particular section of the flowerbed are low, prompting the IoT system to apply fertilizer only in that area, avoiding over-fertilization.

8. Data-Driven Decision Making

IoT generates vast amounts of data that can be analyzed to improve flower cultivation practices. By tracking growth rates, environmental conditions, and resource usage, farmers can make informed decisions about planting schedules, watering, and harvesting.

9. Supply Chain Integration and Flower Quality Monitoring

IoT can help monitor the quality of flowers after they are harvested by tracking temperature and humidity during storage and transportation. This ensures that flowers reach the market fresh and in optimal condition.

- Example: Temperature sensors in refrigerated trucks transporting flowers can send real-time alerts if the temperature rises above acceptable levels, allowing for immediate corrective action.

Challenges of Implementing IoT in Flower Cultivation

1. High Initial Costs. 2. Connectivity Issues. 3. Technical Expertise

Future Prospects of IoT in Flower Cultivation: The adoption of IoT in flower cultivation is expected to grow as the cost of technology decreases and connectivity improves. Advances in 5G networks, AI, and machine learning will enable even more precise control over growing conditions and data analysis. Vertical farming and urban gardening initiatives, which often focus on flowers and ornamentals, will also benefit from IoT, allowing for highly efficient and sustainable production in controlled environments.

Conclusion

Rural women are major stakeholders in growth of agricultural sector for the New India. Acknowledging and mainstreaming of rural women via ensured access to resources, technology, education, and skill development will improve agriculture productivity and help in building an empowered nation. Farm women if devote a small piece of land for flower cultivation, round the year the net income of the family can be increased many folds. Experience of the Krishi Vigyan suggests reveals that the continuous demonstrations on farmers field with a bouquet of technologies can beat the price the fluctuations and when averaged over longer period of time in a year, particularly if the crop was grown in succession for more than nine months.

Volume: 04 Issue No: 12

BIOTECHNOLOGICAL BREAKTHROUGHS IN FRUIT CROP ENHANCEMENT

Article ID: AG-VO4-I12-46

***Manpreet Singh and Monika Gupta**

Department of Fruit Science Punjab Agricultural University, Ludhiana, Punjab, India

Corresponding Author Email ID:* manpreet-2197005@pau.edu

Abstract

Advancements in fruit crop improvement are being revolutionized by biotechnological tools (BTs), offering precise and efficient alternatives to conventional breeding methods, which are limited by challenges like long juvenile periods and high heterozygosity. Techniques such as cisgenesis, RNA interference (RNAi), trans-grafting and gene-editing tools like CRISPR/Cas9 are enabling targeted modifications to enhance traits including disease resistance, stress tolerance and nutritional quality. Cisgenesis and intragenesis used for precise genetic alterations within the same gene pool, while RNAi provides strong protection against pathogens through gene silencing. Trans-grafting combines genetic engineering with traditional grafting to confer resilience to non-GM scions. Gene-editing platforms such as CRISPR/Cas9, have also shown transformative potential in fruit crops for disease resistance. Oligonucleotide-directed mutagenesis (ODM) offers single-nucleotide precision without foreign DNA introduction. Integrating these technologies with traditional breeding holds promise for developing climate-resilient, high-yielding and eco-friendly fruit crop varieties, paving the way for sustainable agricultural practices.

Introduction

Conventional breeding for fruit crops is a slow process, hindered by challenges like high heterozygosity, long juvenile periods and self-incompatibility (Rai and Shekhawat 2014). These limitations make genetic improvement using traditional methods time-intensive. Biotechnological tools including genetic engineering, offer efficient alternatives by enabling precise insertion of desirable genes into the genomes of fruit cultivars. These methods maintain the stability of clonal traits as well as accelerating the genetic advancements (Qaim and Kouser 2013).

Genetic engineering, practiced for over three decades, relies on direct methods like biolistics and indirect methods such as *Agrobacterium tumefaciens*-mediated transformation. The success of these techniques in fruit species often depends on robust *in vitro* regeneration protocols, tailored to the genotype and tissue type. Significant progress has been achieved in regenerating plants from mature tissues, particularly in species like peach and grapevine, which are historically challenging to transform. Biotechnological tools including RNA interference (RNAi), cisgenesis, trans-grafting and gene-editing tools like CRISPR/Cas9 utilize for targeted gene modifications such as insertion, deletion or silencing. While these technologies are widely applied in herbaceous crops, their use in fruit species remains limited, despite their potential to enhance traits like pest resistance, nutritional quality, and stress tolerance (Giuliano 2017).

Cisgenesis and Intragenesis:

Cisgenesis involves genetically modifying plants using genes from the same species or a compatible one, ensuring the introduced gene is a natural variant with its native regulatory elements intact. In contrast, intragenesis uses genetic elements from the same gene pool but creates hybrid genes by combining promoters and terminators from different loci.

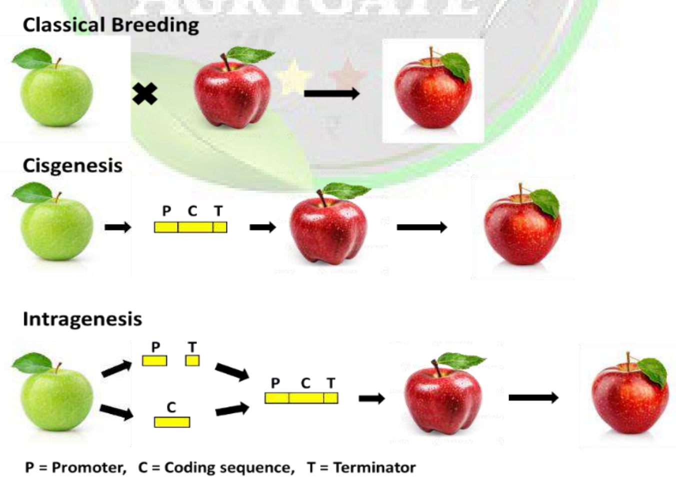


Figure: Cisgenesis and Intragenesis in fruit crops

This approach allows for tailored genetic modifications without introducing foreign DNA, often using plant-derived DNA borders to avoid unintended vector sequences. These methods eliminate "linkage drag"—the unintentional transfer of undesirable traits—and have been used to enhance disease resistance in fruit crops (Jacobsen and Schouten 2007). For instance, cisgenesis was used to develop a fire blight-resistant apple line from the susceptible *Gala Galaxy* variety by introducing a resistance gene (*FB_MR5*) from wild apple (*Malus × robusta*) (Peil et al 2007).

RNA Interference (RNAi):

The discovery of RNA interference (RNAi) in the 1990s revolutionized plant science. Initially observed in petunias, where overexpression of a color gene surprisingly silenced it. RNAi emerged as a natural mechanism for regulating gene expression and defending against harmful nucleic acids. This process involves small RNA molecules (siRNAs and miRNAs) that guide proteins to degrade specific messenger RNAs.

RNAi has been playing a crucial role in developing disease-resistant fruit crops. For instance, transgenic papaya resistant to the Papaya Ringspot Virus (PRSV) was achieved by introducing a viral coat protein gene, which triggered RNA-mediated resistance. Similarly, the *Honeysweet* plum was engineered to resist plum pox virus (PPV) through a post-transcriptional gene silencing (PTGS) mechanism, involving siRNAs that deactivate viral RNA (Ipsaro and Joshua-Tor 2015). Advancements like hairpin RNA (ihpRNA) constructs now enhance RNAi's efficiency, offering great protection against viruses. This technology holds immense promise for combating plant diseases, improving post-harvest quality and conducting functional gene studies in fruit crops.

Trans-Grafting:

Trans-grafting combines traditional grafting with modern genetic engineering to enhance fruit crop resilience and productivity. In this technique, a genetically modified (GM) rootstock is grafted with a non-GM scion. While the scion benefits from the rootstock's traits such as disease resistance or stress tolerance etc. The resulting fruit remains free of genetic modifications (Sunico et al 2024).

The process relies on the transport of small RNA molecules, like siRNAs and microRNAs, through the plant's vascular system, allowing the rootstock to confer protective traits to the scion. For example, RNAi-based rootstocks can transmit virus-resistance signals which can effectively protect the scion from viruses without altering its genetic makeup. Studies have shown these signals can travel long distances within plants, enabling systemic defense against pathogens. Trans-grafting offers an innovative solution to improve crop health, hinder diseases in fruit crops and enhance yield while producing non-GM fruits. Gill et al 2024 discussed the potential of using transgenic rootstocks to confer tolerance to Huanglongbing (HLB) in citrus. This approach has the potential to bypass regulatory hurdles typically associated with GM crops, making it a promising tool for sustainable agriculture.

Table: Applications of trans-grafting in fruit species

Plant species	Source	Trait	Gene name	Achievement	Reference
Apple (*Malus domestica*)	Apple	Control of scion vigor and reduce plant height	rolB	rolB transgenic rootstocks significantly reduced vegetative growth regardless of scion cultivar	Smolka et al 2010
Sweet cherry (*Prunus avium*)	Prunus necrotic ringspot virus (PNRSV)	Resistance to PNRSV in non-transgenic scions	PNRSV	Resistance to PNRSV caused by the transportation (rootstock-to-scion) of hpRNA-derived siRNAs	Song et al 2013

Genome Editing Techniques:

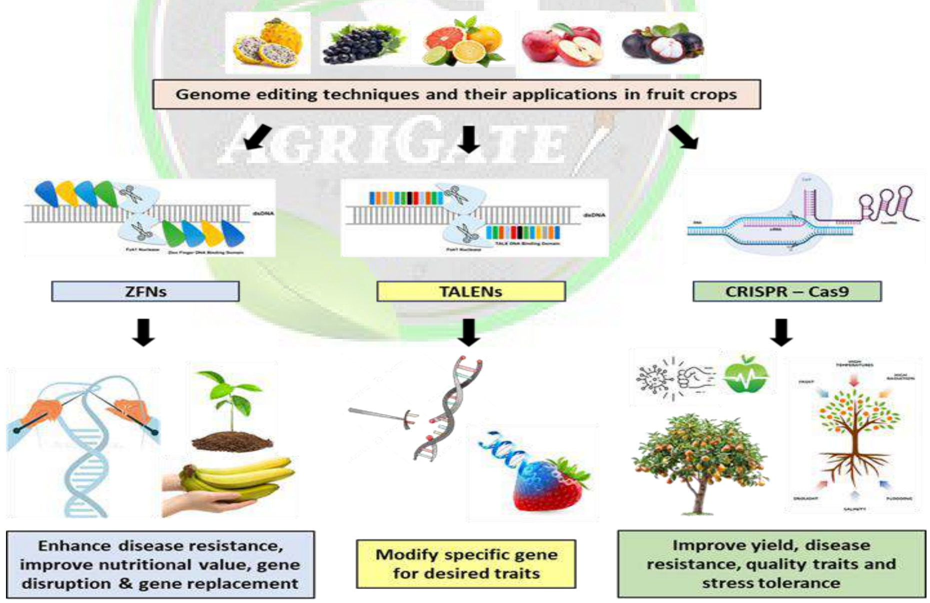


Figure: Application of Genome editing techniques in fruit crops

In the last decade, gene editing has transformed research by allowing precise manipulation of nearly any gene across various organisms. This innovative method uses engineered nucleases (molecular tools combining targeting-DNA and cutting components) to modify genes with exceptional accuracy. By enabling targeted changes, from single-nucleotide edits to larger DNA rearrangements, gene editing not only unlocks new traits in plants but also provides a deeper understanding of biological processes and gene function.

Zinc Finger Nuclease (ZFN) and TALE Nucleases (TALENs)

Zinc Finger Nucleases (ZFNs) and Transcription Activator-Like Effector Nucleases (TALENs) are revolutionary tools used to make precise changes in DNA. These engineered proteins precisely target and cut the DNA at specific sites, allowing to modify genes with high accuracy. By leveraging cellular repair mechanisms, they enable targeted mutations or gene replacements.

- **ZFNs** use zinc finger proteins to identify specific DNA sequences by binding to three base pairs at a time and results in targeted genetic modifications.
- **TALENs** are more flexible using repeating protein units to target individual base pair. The flexibility of this design used for more precise and customizable genetic edits.

In fruit crops, ZFNs have been successfully used in apple and fig, where they repaired a non-functional *uidA* gene in tissue cultures. Edited plants were regenerated with remarkable efficiency up to 100% in fig and up to 40% in apple (Peer et al 2015). These advancements highlight the potential of ZFNs and TALENs to improve fruit crops by adding better traits or increasing disease resistance.

Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and CRISPR-Associated Protein (Cas9)

CRISPR/Cas 9 is simple and precise genome editing tool which has been derived from the immune system of bacteria. Unlike earlier tools like ZFNs and TALENs, CRISPR/Cas9 uses a guide RNA (sgRNA) to direct the Cas9 protein to specific DNA sequences for targeted alterations. This system can be used for "multiplex editing" where multiple genes can be modified simultaneously, offering unmatched flexibility and efficiency. Its affordability and user-friendliness have made it the preferred choice in genetic engineering (Wang et al 2018).

A breakthrough application of CRISPR/Cas 9 in fruit crops was achieved in citrus to combat the deadly Citrus canker. Peng et al 2017 edited the susceptibility gene *CsLOB1* in Wanjincheng orange through the inactivation of disease pathways by the pathogen *Xanthomonas citri*. This edits significantly enhanced resistance, offering hope for safeguarding the global citrus industry. Jia et al 2024 achieved a major advance in citrus canker resistance by using the Cas12a/CBE co-editing method to target the LOB1 susceptibility gene in *Citrus sinensis* cv. Hamlin.

CRISPR/Cas9's versatility is unlocking new possibilities for improving disease resistance and crop productivity in fruit crops.

Oligonucleotide-Directed Mutagenesis (ODM)

Oligonucleotide-directed mutagenesis (ODM) is a gene-editing method designed to make precise changes in a plant's DNA by altering just one or a few base pairs. This is achieved by introducing synthetic DNA or DNA-RNA fragments (20-100 nucleotides long) into plant cells using techniques like electroporation or biolistics. These oligonucleotides bind to their target DNA, creating a mismatch that activates the plant's natural repair mechanisms to fix the sequence and thus results in the desired mutation.

Unlike traditional breeding or mutagenesis, ODM offers precision without introducing foreign DNA, making the resulting plants genetically similar to those produced through conventional methods. However, its application in plants, especially fruit species, remains limited due to challenges like low mutation efficiency and difficulties in regenerating edited plants. While successfully tested in crops like maize and rice, ODM holds untapped potential for more widespread use in agriculture.

Current status and Future thrust:

Biotechnological advancements, including CRISPR/Cas, RNAi and trans-grafting, are transforming fruit crop improvement by enhancing disease resistance, stress tolerance and breeding efficiency. These tools enable precise genetic modifications, reduce breeding cycles and facilitate the production of non-transgenic plants. Techniques like cisgenesis and ODM offer targeted trait enhancement without foreign DNA, preserving genetic integrity. The future focus lies in integrating these technologies with traditional breeding to develop climate-resilient, high-yielding varieties. Research will also emphasize optimizing genome-editing efficiency, expanding applications in recalcitrant species and enhancing sustainable practices for eco-friendly and productive fruit cultivation.

References

Gill, R.A., Li, X., Duan, S., Xing, Q. and Müller-Xing, R., 2024. Citrus threat huanglongbing (HLB)-Could the rootstock provide the cure? *Frontiers in Plant Science*, *15*, p.1330846.

Giuliano, G. (2017). Provitamin A biofortification of crop plants: a gold rush with many miners. Curr. Opin. Biotechnol. 44, 169–180. doi: 10.1016/j.copbio.2017.02.001

Ipsaro, J. J., and Joshua-Tor, L. (2015). From guide to target: molecular insights into eukaryotic RNA-interference machinery. Nat. Struct. Mol. Biol. 22, 20–28. doi: 10.1038/nsmb.2931

Jacobsen, E., and Schouten, H. J. (2007). Cisgenesis strongly improves introgression breeding and induced translocation breeding of plants. Trends Biotechnol. 25, 219–223. doi: 10.1016/j.tibtech.2007.03.008

Jia, H., Omar, A.A., Xu, J., Dalmendray, J., Wang, Y., Feng, Y., Wang, W., Hu, Z., Grosser, J.W. and Wang, N., 2024. Generation of transgene-free canker-resistant Citrus sinensis cv. Hamlin in the T0 generation through Cas12a/CBE co-editing. *Frontiers in Plant Science*, *15*, p.1385768.

Peer, R., Rivlin, G., Golobovitch, S., Lapidot, M., Gal-On, A., Vainstein, A., et al. (2015). Targeted mutagenesis using zinc-finger nucleases in perennial fruit trees. Planta 241, 941–951. doi: 10.1007/s00425-014-2224-x

Peil, A., Garcia-Libreros, T., Richter, K., Trognitz, F. C., Trognitz, B., Hanke, M. V., et al. (2007). Strong evidence for a fire blight resistance gene of Malus robusta located on linkage group 3. Plant Breed. 126, 470–475. doi: 10.1111/j.1439-0523.2007. 01408.x

Peng, A., Chen, S., Lei, T., Xu, L., He, Y., Wu, L., et al. (2017). Engineering canker resistant plants through CRISPR/Cas9-targeted editing of the susceptibility geneCsLOB1promoterincitrus.PlantBiotech.J.doi:10.1111/pbi.12733

Qaim, M., and Kouser, S. (2013). Genetically modified crops and food security. PLoS ONE8: e64879. doi: 10.1371/journal.pone.0064879

Rai, M. K., and Shekhawat, N. S. (2014). Recent advances in genetic engineering for improvement of fruit crops. Plant Cell Tissue Organ Cult 116, 1–15. doi: 10.1007/s11240-013-0389-9

Smolka, A., Li, X. Y., Heikelt, C., Welander, M., and Zhu, L. H. (2010). Effects of transgenic rootstocks on growth and development of non-transgenic scion cultivars in apple. Transgenic Res. 19:933. doi: 10.1007/s11248-010-9370-0

Song, G. Q., Sink, K. C., Walworth, A. E., Cook, M. A., Allison, R. F., and Lang, G. A. (2013). Engineering cherry rootstocks with resistance to Prunus necrotic ring spot virus through RNAi-mediated silencing. Plant Biotechnol. J. 11, 702–708. doi: 10.1111/pbi.12060

Súnico, V., Piunti, I., Bhattacharjee, M., Mezzetti, B., Caballero, J.L., Muñoz-Blanco, J., Ricci, A. and Sabbadini, S., 2024. Overview on Current Selectable Marker Systems and Novel

Marker Free Approaches in Fruit Tree Genetic Engineering. *International Journal of Molecular Sciences*, *25*(22), p.11902.

Wang, X., Tu, M., Li, Z., Wang, Y. and Wang, X., 2018. Current progress and future prospects for the clustered regularly interspaced short palindromic repeats (CRISPR) genome editing technology in fruit tree breeding. *Critical Reviews in Plant Sciences*, *37*(4), pp.233-258.

Wang, X., Tu, M., Li, Z., Wang, Y. and Wang, X., 2018. Current progress and future prospects for the clustered regularly interspaced short palindromic repeats (CRISPR) genome editing technology in fruit tree breeding. *Critical Reviews in Plant Sciences*, *37*(4), pp.233-258.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

DIGITAL LITERACY IN FARMING: OPPORTUNITIES, CHALLENGES AND SOLUTIONS

Article ID: AG-VO4-I12-47

***Sanjay V C[1] and Thokchom Demila[2]**

[1]Ph. D Scholar, Department of Agricultural Extension & Communication, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat-396450, India

[2]Ph.D. Scholar, School of Social Sciences, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya-793103

*Corresponding Author Email ID: sanjayvcappu@gmail.com

Introduction

India is an agrarian country where majority of its residents are still dependent on agriculture for their daily way of life. Agriculture and its allied sectors contribute immensely to the national GDP. As per the Press Information Bureau (PIB) and Ministry of Agriculture and farmers welfare the agriculture and its allied sectors registered a growth rate of 3.4 % during 2020-21 pandemic situation even as overall economic growth declined by -7.2% during the same period. It was the only sector which showed positive growth of during 2020 covid pandemic. (Anonymous 2021). This depicts that agriculture still remained as a backbone of our country's economy. Despite covid-19 shock agriculture sector grows at 3.9% in 2021-22 and 3.6% in 2020-21(Press Information Bureau, GOI, Ministry of Finance)

With the widespread adoption and advancement of modern information technologies such as mobile internet, big data, cloud computing, the Internet of Things (IoT) and blockchain, digitalization has become deeply embedded in all aspects of society, influencing people's lifestyles, learning processes, production methods and thought patterns. As the pace of digital transformation accelerates, the digital footprint of society is expanding rapidly, further widening the digital divide between urban and rural areas. Being an agrarian country, India's comprehensive development can significantly benefit from integrating digital literacy with traditional agricultural wisdom.

Digital literacy was first defined by Paul Gilster in his book Digital Literacy, which is "the ability to understand and use information from a variety of sources, especially through the Internet medium, when information is presented through a computer". Digital literacy for farmers involves the ability to use digital tools like smart phones, computers and internet, to access information, share information, communicate effectively and solve the farmers problems.

For farmers, digital literacy goes beyond simply operating a device; it involves understanding how digital tools can improve farming practices, provide access to markets and enable data-driven decision-making. Advances in agricultural technology are pivotal in driving rural economic growth and boosting the incomes of rural communities. The adoption of digital technology in agriculture is widely acknowledged as a key driver of transformative changes in agricultural production.

Digital Public Infrastructure for Agriculture

Union Finance Minister Nirmala Sitharaman, in the Union Budget 2024-25, announced that the Government, in collaboration with states, will roll out Digital Public Infrastructure (DPI) for agriculture over the next three years. This initiative aims to include farmers and their lands, with a digital crop survey for the Kharif season planned across 400 districts this year. The objective is to update registries with detailed information about 6 crore farmers and their lands. The DPI will integrate with existing state and central digital infrastructures to provide a wide range of farmer-centric services, including insights on livestock, fisheries, soil health and available benefits.

Importance of digital literacy in agriculture

- Digital literacy enables farmers to access real-time information on crop management, pest control, weather conditions and market prices.
- It facilitates direct connections between farmers and buyers through online platforms, ensuring fair pricing and minimizing reliance on intermediaries.
- Farmers can leverage IoT devices and mobile applications to optimize irrigation and the use of fertilizers and pesticides, enhancing efficiency while reducing costs.
- Digital platforms simplify the process of applying for government subsidies, insurance schemes and other welfare programs.
- Tools for weather forecasting and disaster alerts help farmers mitigate risks and prevent crop losses.

- Digital payments and online banking promote financial inclusion, providing farmers with access to loans, credit and insurance services.
- Farmers can stay informed about modern farming methods, global agricultural trends and innovations, enabling them to adopt improved practices.

Principles of Digital Literacy

Digital literacy can be divided into four principles namely:

1. **Comprehension** – the ability to extract digital information, ideas or meanings from a media.

2. **Interdependence** – the ability to connect between one media form with another for the data, content and platforms whether potentially, metaphorically, ideally or literally.

3. **Social Factors** – understanding the impact of creating communities online and building personal resilience as well as self-protection.

4. **Curation** – the ability to understand the value of information and storing it for long time to easily accessible.

Types of Digital Literacy

Aviram and Eshet-Alkalai contend that five types of literacies are encompassed in the umbrella term that is digital literacy.

1. **Reproduction literacy**: the ability to use digital technology to create a new piece of work or combine existing pieces of work to make it your own.
2. **Photo-visual literacy**: the ability to read and deduce information from visuals.
3. **Branching literacy**: ability to successfully navigate in non-linear medium of digital space.
4. **Information literacy**: the ability to search, locate, assess and critically evaluate information found on the web and on-shelf in libraries.
5. **Socio-emotional literacy**: the social and emotional aspects of being present online, whether it may be through socializing and collaborating or simply consuming content.

Current status of DL among farmers

In 2023, the Internet and Mobile Association of India (IAMAI) reported that while 60% of Indian adults were online, only 29% of those in rural areas had internet access. This indicates that the majority of farmers are unable to engage in the agricultural digital revolution. Furthermore, a 2022 World Bank survey revealed that just 23.4% of rural Indian adults possess basic digital literacy skills. This lack of digital proficiency makes it difficult for farmers to effectively use digital tools, navigate online platforms and access crucial information.

Measures to promote digital literacy among farmers

- **Expand Digital Infrastructure in Rural Areas:** Improve internet connectivity and mobile network coverage in rural regions to support the efficient use of digital agriculture platforms.
- **Promote Digital Literacy Training:** Organize regular training sessions to increase farmers' awareness and adoption of digital technologies, such as those conducted by MANAGE to help farmers effectively use digital tools.
- **Ensure Language and Accessibility Support:** Develop user-friendly platforms in local languages to address language barriers and make digital tools more accessible.
- **Collaborate with Agri-Tech Startups:** Partner with agri-tech startups to deliver cost-effective solutions tailored to small and marginal farmers, increasing digital adoption.
- **Prioritize Affordability and Accessibility:** Offer subsidies for expensive equipment and ensure technological tools remain affordable and easily accessible for small-scale farmers.

Challenges in implementing DL

1. **Limited Access to Technology** - In many rural areas, farmers have limited access to digital devices, as well as reliable internet connectivity. This digital divide makes it difficult for them to benefit from the tools and information available online.
2. **Lack of Training and Education** - Digital literacy requires more than just owning a device—it involves understanding how to use it to enhance farming practices. Without proper training, farmers may struggle to adopt these new technologies.
3. **High Costs of Technology** - The costs associated with purchasing and maintaining digital tools can be prohibitive for many farmers, especially small-scale operators as they may not be able to afford the technology needed to become digitally literate.
4. **Cultural and Language Barriers**: In some regions, cultural and language barriers can hinder the adoption of digital tools. For example, if digital tools are only available in certain languages, farmers who do not speak those languages may struggle to use them effectively.

5. **Resistance to Change** – some farmers may be resistant to adopting new technologies, either due to a lack of understanding or a preference for traditional methods which lacks digital literacy for farming.

Digital literacy programmes

1) **Digital India Program (2015)**: It strives to transform India into a digitally empowered society and a knowledge-driven economy. The initiative emphasizes key areas such as infrastructure development, citizen digital empowerment and the digital delivery of government services.
2) **Pradhan Mantri Gramin Digital Saksharta Abhiyaan (PMGDISHA, 2017):** It is a Digital Literacy Scheme by the Ministry of Electronics and Information Technology, to make six crore persons in rural areas, across States/UTs, are digitally literate, reaching around 40% of rural households by covering one member from every eligible household.
3) **National Digital Literacy Mission (NDLM, 2014):** The NDLM seeks to provide digital literacy training to at least one member of every household in targeted states and union territories. It prioritizes marginalized groups, such as women, minorities and differently-abled individuals, to promote inclusive participation in the digital revolution.
4) **National Institute of Electronics and Information Technology (NIELIT):** NIELIT offers various digital literacy courses and certifications for all age groups.
5) **National Digital Library of India (NDLI, 2018):** It is a digital repository of learning resources that provides access to a vast collection of e-books, e-journals, and other educational materials. It promotes self-learning and lifelong learning opportunities, contributing to the enhancement of digital literacy among students and educators.
6) **Cyber Swachhta Kendra (Botnet Cleaning and Malware Analysis Centre, 2017):** This government initiative aims to raise cybersecurity awareness and provide support to citizens. It offers tools and resources to detect and remove malware, fostering safe and secure digital practices among internet users.
7) **Scheme for Promotion of Information Technology in Rural India (SPIRIT):** This digital literacy program provides financial assistance to NGOs and institutions for setting up rural IT training centers.

Conclusion

Digital literacy is crucial for empowering Indian farmers to enhance agricultural productivity, access markets and improve their livelihoods. Despite advancements in technology, a significant digital divide persists, especially in rural areas, limiting farmers' access to vital resources and tools. Government initiatives like DPI for agriculture and targeted digital literacy programs aim to bridge this gap and make farming more efficient and sustainable. However, challenges such as limited infrastructure, high costs and cultural barriers must be addressed to ensure the successful implementation of these programs. By fostering digital inclusivity, India can unlock the full potential of its agrarian economy and drive comprehensive rural development.

References

Anonymous (2021). Press Information Bureau (PIB) and Ministry of Agriculture and farmers welfare GOI. 1st advance estimates of national income, 2020-21. https://pib.gov.in/Pressreleaseshare.aspx?PRID=1697512 Accessed on 27th November 2024.

Aviram, Aharon; Eshet-Alkalai, Yoram (2006-04-03). "Towards a Theory of Digital Literacy: Three Scenarios for the Next Steps". *European Journal of Open, Distance and E-learning*. **9** (1). ISSN 1027-5207

https://pib.gov.in/newsite/PrintRelease.aspx?relid=231156#:~:text=DESPITE%20COVID%2D19%20SHOCK%20AGRICULTURE,AND%203.6%25%20IN%202020%2D21&text=The%20Agriculture%20sector%20which%20accounts,in%20the%20past%202%20years.

https://samunnati.com/bridging-the-digital-divide-unveiling-challenges-for-indian-farmers-in-a-digital-age/#:~:text=The%20Digital%20Divide:%20A%20Hurdle,their%20lack%20of%20digital%20fluency.

https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2051719#:~:text=Union%20Finance%20Minister%20Nirmala%20Sitharaman,soil%20health%2C%20and%20available%20benefits.

https://www.teachthought.com/literacy/digital-literacy/

Volume: 04 Issue No: 12

TURMERIC RESIDUES TO TREASURE: OPTIMIZING ACTIVATEDCARBON PRODUCTION FOR SUSTAINABLE APPLICATIONS

Article ID: AG-VO4-I12-48

***S. Vanisha[1], T. Dhanya[2], V. Rithanya[3], V. Udhayakumar[4] and G. Yashmin[5]**

Department of Agricultural Engineering, Nandha Engineering College, Erode-52, Tamil Nadu, India

*Corresponding Author Email ID: vanishas2001@gmail.com

Introduction

Turmeric (Curcuma longa L.), a perennial plant belonging to the Zingiberaceae family, has been traditionally utilized as a medicinal herb, dietary spice, food source, and food preservative. In Tamil Nadu, Erode is renowned for turmeric cultivation producing about 31867.7 tonnes of the spiceannually contributing 33.37 per cent of the total turmericproduction in the state. The district's 24.14 per cent (9473hectares) of the total area is used for turmeric cultivation. In the Erode district, turmeric is cultivated on approximately 7,960 hectares, yielding a total production of 41,153 tonnes per year. However, a significant portion of the agro-residues, approximately 40%, are wasted. Turmericfarming generates significant agricultural residues like FieldResidues (Leaves, Stems and roots) and Processing Residues(Boiling Residue, Peelings and Fibrous Material) which if leftuntreated, contributes to environmental pollution.

The fixed carbon content of the turmeric residues varies across different plant parts: Turmeric roots (rhizomes) contain 30-40% fixed carbon, Turmeric leaves contain 15-20%, and Turmeric stems contain 20-25%. By utilizing these fixed carbon contents, activated carbon can be produced through carbonization and physical activation techniques, which involve transforming turmeric residue into a highly porous and reactive material with enhanced surface area and adsorption capacity.The strategic conversion of waste into valuable resources is pivotal in mitigating environmental degradation. By transforming waste into usable products such as energy, materials, or fertilizers, we can foster a culture of sustainability and propel the transition towards a circular economy. The production of activated carbon involves a two-stage process, where carbon-rich materials are first thermally treated in an oxygen-free environment to create a carbonized material. This is then followed by an activationstep, where the material is exposed to gases, resulting in a highly porous structure with an enhanced surface area. This unique structure enables activated carbon to effectively adsorb impurities, making it an indispensable material invarious applications, including water treatment, air purification, and industrial chemical processing.

1. ACTIVATED CARBON PROCESS

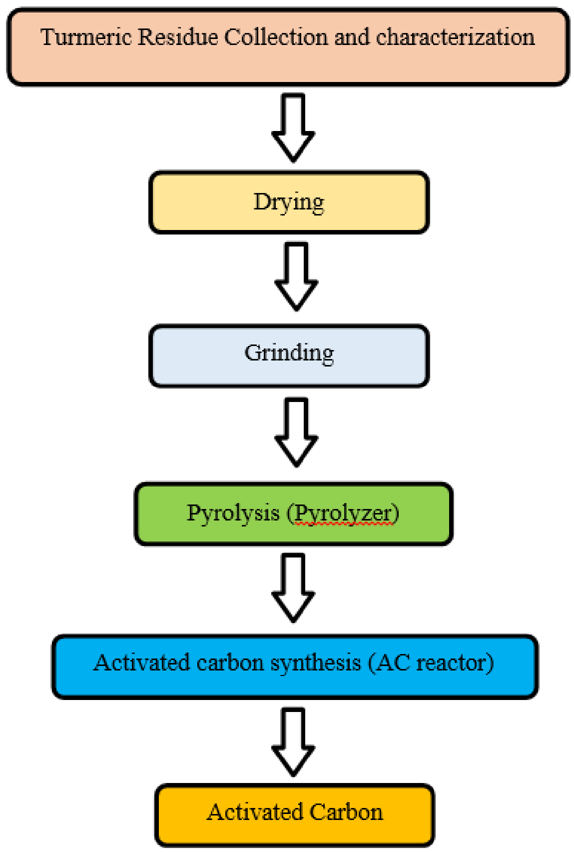


Fig 1. Methodology of Activated Carbon

1.1. TURMERIC RESIDUE COLLECTION AND CHARACTERIZATION

Turmeric residue, a byproduct of curcumin extraction, is typically collected from turmeric processing units or industries involved in spice and herbal production. The collection process involves gathering the fibrous material left after curcumin extraction, ensuring it is free from contaminants such as dust, soil, and chemical residues.Once collected, the residue is air-dried or oven-dried to reduce moisture content and preserve its integrity for further analysis. Characterization of turmeric residue involves evaluating its physical, chemical, and nutritional properties.

Physical Characteristics

Fibrous Structure: Turmeric residues exhibit a robust, fibrous structure comprising cellulose, hemicellulose, and lignin.

Moisture Content: The moisture content is moderate, necessitating drying for specific applications.

Granular or Paste-like Form: Depending on processing methods, the residues may appear as coarse granules or a fine paste.

Chemical Composition

Cellulose and hemicellulose (40-60%): Primary constituents with potential applications in bioenergy and biopolymer production.

Lignin (15-30%): Provides structural integrity and can be utilized for biochar or activated carbon production.

Curcuminoids and essential oils (trace amounts): Residual bioactive compounds possessing antimicrobial and antioxidant properties.

Ash and starch content (5-10%): Minor components contributing to mineral and energy content.

Sustainability Aspects

Waste valorization: Converts agro-industrial waste into valuable products, reducing environmental impact.

Fig 2. Turmeric Residues Collection

Renewable resource: Turmeric residues are a sustainable, annually renewable feedstock, promoting circular economy practices.

Reduced landfill use: Utilizing residues minimizes waste disposal and mitigates pollution, contributing to sustainable waste management.

DRYING: Drying is a crucial step in converting turmeric residues into activated carbon. Excess moisture removal ensures efficient carbonization and activation. Fresh residues contain high moisture, which can hinder pyrolysis if not reduced. Proper drying preserves biomass structure, ensures uniform moisture removal, and achieves optimal moisture content (<10%) for carbonization. The drying process significantly influences the final activated carbon product's porosity, surface area, and adsorption capacity, making it a key factor in producing high-quality activated carbon from turmeric residues

Fig 3. Dried Residues

1.2. GRINDING: The conversion of turmeric residues into activated carbon involves a crucial grinding process that enhances the material's surface area, facilitating efficient carbonization and activation. Initially, the dried turmeric residues, often fibrous and coarse, are subjected to mechanical grinding using milling equipment such as hammer mills, ball mills, or pulverisers. This process reduces the residue into fine particles, increasing its surface area-to-volume ratio, which is essential for effective activation.

1.3. PYROLYSIS (PYROLYZER): Pyrolysis is a thermochemical process that effectively converts turmeric residues into activated carbon. This process involves heating the residues in an oxygen-free environment within a pyrolyzer at temperatures between 400°C to 800°C. Thermal decomposition occurs, breaking down organic components into volatile gases, bio-oil, and a solid carbon-rich char. This char serves as a precursor for activated carbon production. To enhance adsorption properties, the char undergoes activation through physical or chemical methods. Physical activation involves heating the char with steam or CO_2 at high temperatures, creating a porous structure. Chemical activation involves impregnating the char with activating agents, developing a high surface area and well-distributed micropores.

1.4. ACTIVATED CARBON SYNTHESIS:

Physical Activation

Carbonization Stage: During this initial stage, raw materials such as wood, coconut shells, or other carbon-rich substances are heated to high temperatures, typically ranging from 400°C to 800°C. This process takes place in an inert atmosphere, which prevents the material from burning or reacting with oxygen.The carbonization stage transforms the raw material into a carbon-rich solid, which is then prepared for the activation stage.

Activation Stage: In the activation stage, the carbonized material is exposed to oxidizing gases such as steam or carbon dioxide at elevated temperatures, typically between 800°C to 1100°C.This activation process significantly enhances the surface area and pore structure of the carbon material, making it highly porous and suitable for various gas-phase applications.

Chemical Activation

Chemical Activation Process for Enhanced Porosity: The chemical activation process involves impregnating raw materials with specific chemical agents to enhance their porosity and surface area. This method is particularly effective for producing activated carbon suitable for liquid-phase applications.

Impregnation with Chemical Agents: Raw materials are treated with chemical agents such as phosphoric acid (H_3PO_4) or potassium hydroxide (KOH). These agents facilitate the creation of a more porous structure, allowing for increased surface area and adsorption capacity.

Thermal Treatment at Lower Temperatures: Following impregnation, the raw materials are heated to lower temperatures, typically ranging from 400°C to 600°C. This thermal treatment enhances the porosity and surface area of the material, resulting in a higher surface area carbon.

Optimization

Temperature: Temperature significantly impacts the structural properties of activated carbon. Higher temperatures (800°C-1000°C) enhance pore formation, increasing surface area and adsorption capacity.

Time: Activation time is crucial in producing high-quality activated carbon. While longer times enhance pore development, excessive time can lead to over-carbonization, reducing yield. Finding the optimal balance between time and yield is essential.

Pressure: Controlled pressure is crucial in the activation process, enabling uniform pore development in activated carbon. Precise pressure regulation allows manufacturers to customize the pore structure for specific applications, optimizing performance and efficiency.

Chemical Agents: Chemical agents like phosphoric acid (H_3PO_4) and potassium hydroxide (KOH) play a crucial role in the activation process, influencing activated carbon's properties. KOH is often used to produce high-surface-area activated carbon, while H_3PO_4 enhances mesoporosity for improved adsorption of larger molecules.

Concentration: The concentration of the activating agent is crucial in the activation process. Optimal results are achieved with concentrations between 30% and 50%, which balance porosity and chemical residue, maximizing adsorption capacity while minimizing environmental impact.

Physical Pretreatment: Physical pretreatment is crucial in the activation process, improving uniformity and efficiency. Techniques like grinding and drying remove excess moisture and minimize particle size, allowing for even penetration of activating agents and a more efficient activation process.

Chemical Pretreatment: Chemical pretreatment is a crucial step in the activation process, removing impurities and boosting efficiency. Acid or alkali washing cleans the raw material, enabling activating agents to penetrate uniformly and efficiently, resulting in high-quality activated carbon with improved properties.

Biological Pretreatment: Biological pretreatment uses enzymatic or microbial treatments to enhance activated carbon properties. By reducing lignin content, this approach improves porosity and reactivity of the final product.

Sieve separation: Sieve separation is a critical step in activated carbon production, ensuring uniform particle size distribution, which affects adsorption efficiency and application suitability. The process involves passing crushed activated carbon through sieves or screens with different mesh sizes to classify particles by size, with mesh size selection depending on the intended application.

Fig.4. Activated Carbon

2. APPLICATIONS OF ACTIVATED CARBON FROM TURMERIC RESIDUES

Fig.5. Application of Activated Carbon

3. ECONOMIC AND ENVIRONMENTAL IMPACT

Producing activated carbon from turmeric residues is a cost-effective and eco-friendly method. It saves costs by utilizing waste material and requiring minimal equipment and energy. This approach also reduces environmental impact by repurposing waste biomass, eliminating harsh chemicals, and conserving energy. It promotes a circular economy and is a sustainable solution for industries seeking to minimize their environmental footprint while reducing costs.

Conclusion

Producing activated carbon from turmeric residues offers a sustainable solution for waste management and environmental remediation. This closed-loop system minimizes waste and pollution while optimizing resource efficiency. Future research can build upon this approach to enhance sustainability and viability, contributing to global sustainability goals, economic growth, environmental stewardship, and social responsibility.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

HARVESTING, HANDLING AND GRADING OF CUT FLOWER

Article ID: AG-V04-I12-49

H. Dharshini*

B.Sc. (Hons.) Horticulture, R.V.S. Padmavathy College of Horticulture, Sempatti, Dindigul, Tamil Nadu, India – 624707

*Corresponding Author Email ID: dharshiniharichandran@gmail.com

Introduction

Cut flowers harvesting is a critical stage in the floral industry influence quality, and vase life. Factors affecting handling such as temperature, humidity, ethylene sensitive are examined. Most flowers are unaffected by the levels of ethylene that are expected to be present during marketing. However, if ethylene sensitivity exposure while handling. Silver thio sulphate is an example of an product. Flowers are frequently sorted and bunched soon after harvesting before being placed in water. This approach reduces handling steps and minimise mechanical damage that frequently occur on the flowers.

Introduction

Cut flowers are highly and typically survive 10 to 28 days in a vase with holding solution. After harvesting flower should be in a cool environment with chemical preservative and nutrient solutions according to their unique needs. Cut flowers post harvest, Life is affected by cell turgidity, dry stem ends and bacterial development, which can reduce water uptake and cause stems to droop and blooms to wilt. The majority of farmers and dealers cut flowers are highly perishable and typically survive 10 to 28 days in a vase with holding solution had insufficient understanding of effective pre and post harvest handling practices, which contributed significantly to significant postharvest losses in cut flower.

a. Harvesting of cut flowers

It should be cut using sharp knives or secatures. To enable rapid water absorption, hardwood stems should always be slanted sliced to expose the most surface area possible.

Cutting dahlia and poinsettia blooms causes latex to be released. To reduce this issue, stems should be immersed in hot water (80-90°C) for a seconds.

Flowers should be harvested at right stage of development to ensure optimal vase life. Some species may be harvested at a less mature stage during the summer, warm temperature can cause rapid growth. Morning harvest are frequently preferable to afternoon harvest since the temperature is lower, the remainder of the day is free for packing and the distribution.

S. No.	Crops	Harvesting stage
1.	Cut rose	Harvesting is done with a secature at the right bud stage, when the colour is fully established.
2.	Gladiolus	It flowers are ready for harvest when the lower 1-3 florets to be cut once the bottom flower on the spike has opened. Picking is done generally by keeping atleast 4-5 basal leaves of the plant.
3.	Carnation	Paint brush stage: Standard carnations should be harvested when the outer petal is approximately perpendicular to the stem. Spray carnations are taken when two blooms are blooms are open and the bud show color.
4.	Gerbera	Gerbera flowers are ready for harvesting when the outer 2-3 rows of disc florets are perpendicular to the stalk and the blooms are fully open.
5.	Cut chrysanthemum	Standard form of chrysanthemum flowers are picked when 2-3 rows of ray florets are perpendicular to the flower stalk.
6.	Anthurium	Anthurium flowers are plucked after spathe entirely unfurls and the spadix is fully formed.
7.	Tuberose	Tuberose flowers are ready for harvest when the lower 1-3 florets open, which typically occur 3-3.5 months after sowing. Spikes are picked during the bud-burst stage,

		ideally in the morning.
8.	Bird of paradise	It is ready to harvest when the first orange blossoms develop or when it is in the tight bud stage.
9.	Heliconia	Harvesting occur when the outer section of the peripheral ring of the flower open.
10	Yellow aster	Harvested when outer region ring of flowers are open.

b. Handling of cut flowers

Ethylene

Construct storage and handling to prevent ethylene contamination and provide ample airflow. Treatment with silver's anionic thiosulphate (STS) or the novel gaseous inhibitor, MCP (Ethylbloc), decreases the effects of ethylene (exogeneous or endogeneous) on particular cells. Refrigerated storage reduces production and product sensitivity.

Precooling

Use hydrocooling or refrigerations to remove surplus heat from the field. Minimise the time of harvest and precooling.

It reduce the respiration rate. Precooling temperatures for rose from 1 to 3°C,

chrysanthemums from 0.5to4°C,

carnations from 1°C, and gladiolus from 4.0°C.

Impregnation

Impregnation occurs when flowers are loaded with high concentration of silver nitatre or cobalt chloride for a brief time. This reduce bacteria activity and ethylene synthesis

Water supply

Van Doorn (1995) found that acidic water with a pH of 3 to 3.5 inhibit microbial development. Cut flowers with leafy stems lose water quickly due to their vast surface area. To prevent the water loss during long term storage, keep relative humidity levels over 95%. Low temperature strongly reduce water loss.

Sugars

It serves as an additional food source and helps water balance. Sugars can increase microbial development, hence they usually come together with a biocide. Glucose (reducing sugar) is the most efficient sugar for extending vase life, followed by fructose.

Chemical preservatives

Chemical preservatives such as citric acid, boric acid, ascorbic acid, aluminium sulphate, cobalt sulphate, calcium chloride, 8HQC and there have been employed in variety of formula and combination to extend floral vase life.

Irradiation

Irradiation of plant cells has been extensively researched. This method inhibits or destroys bacteria without using antibacterial chemicals or metabolic products as preservatives.

Irradiation can occur by non ionising radiation (eg., less energetic UV radiation) or ionising radiation (eg., gamma rays, electron beams and X-rays.

Air transport of cut flowers

For example, a dry-ice refrigeration system can provide controlled temperatures for cut flowers, allowing for long distance transportation at a cost that is justified by the improved quality of the flowers upon arrival.

Passively chilled and insulated containers offer an alternate method of controlling temperatures during transportation. If the product is appropriately cooled before being palletised or packaged in an LD-3 container, insulation alone will undoubtly improve temperatures management along the transportation chain. Given the lack of temperatures control in the majority of aeroplanes carrying cut flowers and the strong reaction of cut flowers to temperatures abuse, the logistics for air transport of cut flowers must focus on doing all possible to preserve the cold chain.

c. Grading of cut flowers

Designating grade requirements for cut flowers is a continuous issue in their maintenance.

Stem length, a common quality measures for flowers, may not accurately reflect the quality, vase life, or usefulness. The weight of a bunch per length is a reliable indicator of flower

Cut roses

S. No.	Grading	Stalk length
1.	Extra class	70-80cm
2.	Class 1	60-70cm
3.	Class2	50-60cm

Gladiolus

S. No.	Grade	Spike length	Number of florets
1.	Fancy	More than 107 cm	16
2.	Special	96-107 cm	15
3.	Standard	81-90 cm	12

Gerbera:

S. No.	Stem length
1.	More than 60 cm
2.	50-60 cm
3.	40-50 cm
4.	30-40 cm
5.	Less than 30 cm

Conclusion

Flowers and living plants are extremely sensitive to manipulation. Harsh manipulation produce damage, leading to ethanol production. Flowers and plants are quickly destroyed. Using a bad temperature causes flowering, maturation, wilting an rotting. Good is unsellable. To maintain quality standards in international trade, transport and logistics providers must use temperature controlled trucks and equipment. Accurate instructions from flower and plant producers and sellers are crucial for transport and logistics organisation, as they are part of the supply chain.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

INSTRUMENT OF PRECISION FARMING

Article ID: AG-VO4-I12-50

Naresh Kumar[1*], Ronak Kuri[2], Mahendra Junjariya[1] and Sachin Yadav[3]

[1]Ph.D. Research Scholar, Department of Agronomy, Agriculture University, Jodhpur

[2]Ph.D. Research Scholar, Department of Horticulture, Agriculture University, Jodhpur

[3]Ph.D. Research Scholar, Department of Entomology, MPUAT, Udaipur

*Corresponding Author Email ID: patelnaresh1114@gmail.com

Introduction

Precision farming is an information and communication technology driven agricultural management system to characterize, interpret, manage, and monitor spatial and temporal variability of soils, crops within a field for profitability, sustainability and environmental protection is a farming management concept based on observing and responding to in-field variability. The management of in-field variability in soil fertility and crop conditions for improving the crop production and minimizing the environmental impact is the crux of precision farming. Agriculture or site-specific crop management can be defined as the management of spatial and temporal variability at a sub-field level to improve economic returns and reduce environmental impact. It is in-fact applying the right input, in right amount, in the right place, in the right manner, and at the right time. Today, precision agriculture is about whole farm management with the goal of optimizing returns on inputs while preserving resources.

It relies on new technologies like satellite imagery, information technology, and geospatial tools. It is also facilitated by farmers' ability to locate their precise position in a field using satellite positioning system like the Global Positioning System (GPS) or other GNSS. Precision agriculture aims to optimize field-level management with regard to Crop science by matching farming practices more closely to crop needs (*e.g.* fertilizer inputs); environmental protection by reducing environmental risks and footprint of farming (*e.g.* limiting leaching of nitrogen); and economics by boosting competitiveness through more efficient practices (*e.g.* improved management of fertilizer usage and other inputs). Precision agriculture also provides farmers with a wealth of information to build up a record of their farm; improve decision-making; foster greater traceability; enhance marketing of farm products; improve lease arrangements and relationship with landlords and enhance the inherent quality of farm products (*e.g.* protein level in bread-flour wheat).

❖ **The list and brief description of certain instruments used in precision framing is give as follows:**

Name of instrument	**Description**	**Uses**
1. Global positioning System (GPS) 	It is space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver.	The most common civilian applications to date have been land, air and marine navigation, and surveying. More recent applications include agriculture, aircraft precision approach, robotics, intelligent traffic systems, construction, resource extraction, and geographic information systems (GIS). In precision framing, planting, scouting, spraying or harvesting, can be referenced to using coordinates (latitude and longitude). Latitude and longitude are the unique address of every inch of ground on the face of

		the earth, and that's what the GPS receiver reports. We can use this unique address to store information and plan activities for each location. Examples include: soil sampling and dynamic nutrient map making, variable-rate fertilization, machine guidance for planting and spraying with variable rates, yield monitoring and making yield maps
2. Hyperspectral Camera 	Hyperspectral cameras are those that can capture information in the electromagnetic spectrum, far beyond what the human eye — and consumer cameras — can see. Hyperspectral imaging, like other spectral imaging, collects and processes information from across the electromagnetic spectrum. Much as the human eye sees visible light in three bands (red, green, and blue), spectral imaging divides the spectrum into many more bands.	These systems can effectively monitor the health of crops, 'seeing' water and nutrient levels and the presence of hard- to-spot diseases. They can provide access to challenging areas such as swamps, Antarctica, and mountainous regions. Hyperspectral imaging has enabled many advances in precision agriculture. Precision agriculture requires more than just basic RGB information. For example, video images flying over a

	This technique of dividing images into bands can be extended beyond the visible.	field would not be able to accurately distinguish real plants from fake ones. Looking at the spectral content in the pixels, hyperspectral solutions can detect chlorophyll or very small color-changes on foliage. Color information can be useful to distinguish brown from green, but more bands are required for finer details
3.GreenSeeker® 	GreenSeeker® is an integrated optical sensing and application system that measures crop status and variably applies the crop's nitrogen requirements. The sensor uses light emitting diodes (LED) to generate red and near infrared (NIR) light. The light generated is reflected off of the crop and measured by a photodiode located at the front of the sensor head.	It helps measuring the real-time N status of crop and variable N-application. The GreenSeeker® applies the right amount of N at the right place and at the right time thereby optimizing yield and N input expense. Yield potential for a crop is identified using a vegetative index known as NDVI (normalized difference vegetative index) and an environmental factor.

		Nitrogen (N) is then recommended based on yield potential and the responsiveness of the crop to additional nitrogen.
4.Chlorophyll meter (SPAD meter) 	The chlorophyll meter or SPAD meter is a simple, portable diagnostic tool that measures the greenness or relative chlorophyll content of leaves. Meter readings given in the form of digital SPAD (Soil Plant Analysis Development) values indicate relative chlorophyll content of plant leaf.	The SPAD 502 Plus Chlorophyll Meter instantly measures chlorophyll content or “greenness” of plants to reduce the risk of yield-limiting deficiencies or costly over-fertilizing. The SPAD 502 Plus quantifies subtle changes or trends in plant health long before they’re visible to the human eye. Non-invasive measurement; simply clamp the meter over leafy tissue, and receive an indexed chlorophyll content reading (-9.9 to 199.9) in less than 2 seconds.
5.Soil moisture sensors	Soil moisture sensors measure the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors. Common type of soil moisture sensors in commercial use is a frequency domain sensor such as	Measuring soil profile moisture periodically for precise irrigation scheduling. It will help in deciding time of irrigation and determining net irrigation requirement.

	a capacitance sensor. Another sensor, the neutron moisture gauge, utilize the moderator properties of water for neutrons. Time domain transmission (TDT) and time domain reflectometry (TDR) is also used to measure moisture content; water has a high dielectric constant; a higher water concentration causes a higher average dielectric constant for the soil. The average dielectric constant can be sensed by measuring the speed of propagation along a buried transmission line	
6.Variable rate applicator (Fertilizer spreader) 	The major components of a typical variable rate control system consist of an in–cab computer loaded with application software and variable rate application maps, a global positioning system (GPS) receiver that provides vehicle position information to the computer, and a controller that controls material rates under direction of the computer. When the equipment is operating in the	Variable rate applicator (VRA) is needed for implementation of precision farming especially for applying fertilizer in the field. Utilizing the VRA machine, fertilizer could be given in precise dose and placed at accurate location in the field. It can be map based or sensor based. *Variable rate* fertilization aims to improve fertilizer use

	field, the computer receives position information, matches the required application rate as a function of vehicle position, and then sends a set–point signal to the controller that adjusts the application to the desired rate. A variable rate system may also record actual application rates along with GPS position.	efficiency and reduce leaching by varying fertilizer rates according to the needs of each area within a field.
7.Yield monitor 	The combine grain yield monitor is a device coupled with other sensors to calculate and record the crop yield or grain yield as a modern day combine harvester operates.	Yield monitors provide producers with the tools to reduce costs, increase yields, and increase efficiency. The present-day grain yield monitor is designed to measure the harvested grain mass flow, moisture content, and speed to determine total grain harvested. In most cases today this is coupled with global positioning system to record yield and other spatially variable information across a field. This allows for the creation of a grain yield map which provides information on spatial variability.

Volume: 04 Issue No: 12

INTELLECTUAL PROPERTY ECOSYSTEM AND IPR MANAGEMENT IN INDIA

Article ID: AG-VO4-I12-51

***Sanjay V C[1] and Jyoti Uppar[2]**

[1]Ph. D Scholar, Department of Agricultural Extension & Communication, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat – 396450, India

[2]Ph. D Scholar, Department of Plantation crops and Processing, Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal - 736165

*Corresponding Author Email ID: sanjayvcappu@gmail.com

Introduction

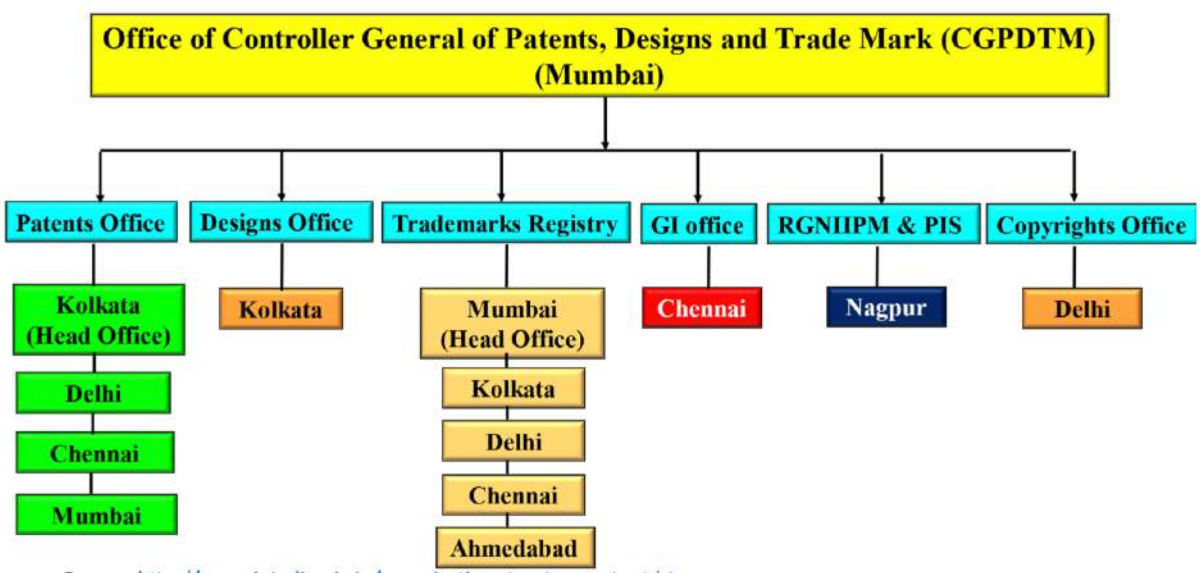
A strong Intellectual Property Rights ecosystem provides legal protection and rewards for the creators' innovations. This incentivizes individuals and businesses to invest in research and development, fostering a culture of continuous innovation. As a result, the nation can advance in both technologically and economically which will be helpful in progress of the nation. An intellectual property (IP) ecosystem is a complex network of relationships between IP creators, legal teams, law firms, and other entities. The success of an IP ecosystem depends on collaboration, strategic use of technology, and a willingness to connect. As the Intellectual Property ecosystem is quite vast and varied, each country has established dedicated bodies for the promotion, administration and implementation of IP activities. In India, the key organizations engaged in IP affairs are mentioned below

Categories of Intellectual Property Rights and their governing bodies in India.

Type of IP	**Governing Body**
Patents Copyrights Industrial Designs Trademarks	Department for Promotion of Industry and Internal Trade (DPIIT) New Delhi

Geographical Indications Semiconductor Integrated Circuits Layout-Design	
Traditional Knowledge Digital Library (TKDL)	CSIR & Ministry of AYUSH
Plant Variety Protection	Ministry of Agriculture and Farmers Welfare, New Delhi
Biological Diversity Protection	Ministry of Environment, Forest and Climate Change, New Delhi
Trade Secrets	No specific body governs Trade Secrets. But protected under Copyright Act (1957) Information Technology Act (2000), etc.

Institutional arrangement



Source: http://www.ipindia.nic.in/organization-structure-patent.htm

The office of CGPDTM situated in Mumbai administers all the acts and laws related to patents, trademarks, industrial designs, geographical indications, copyrights and semiconductor integrated circuits layout-design registry.

- **Patent offices**

Govt bodies that grant a patent based on whether the application fulfils the criteria requirements for patentability. The Patent Office functions under the superintendence and control of the CGPDTM, Mumbai. The Patent Office discharges its statutory functions in accordance with the provisions of the Patents Act, 1970 (as amended) and corresponding Patents Rules, 2003 (as amended) and the Designs Act, 2000 and corresponding Designs Rules, 2001 (as amended), respectively.

Sl. No.	Patent office	Jurisdiction (States and Union territories)
1.	Patent Office, Chennai	Andhra Pradesh, Kerala, Tamil Nadu, Karnataka Pondicherry and Lakshadweep Island.
2.	Patent Office, Delhi	Jammu & Kashmir, Rajasthan, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Delhi, Chandigarh.
3.	Patent Office, Kolkata	Arunachal Pradesh, Assam, Bihar, Jharkhand, Orissa, West Bengal, Manipur, Mizoram, Meghalaya, Sikkim, Tripura, Nagaland, Andaman & Nicobar Islands
4.	Patent Office, Mumbai	Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh, Goa, Daman& Diu and Dadra & Nagar Haveli.

- **Design Office**

  It provides legal protection for preventing other businesses from copying, selling, or duplicating their products with a similar design to the original.

- **Trademark Registry**

  It is to register trademarks which qualify for registration as per provisions of the Trade Marks Act and Rules, and to maintain the Register of trademarks. Trade Marks Registry discharges its statutory functions in accordance with the provisions of the Trade Marks Act, 1999 and the Trade Marks Rules 2017.

Sl. No.	Trade Marks Registry office	Jurisdiction (States and Union territories)
1.	Trade Marks Registry office, Mumbai (Head Office)	Maharashtra, Madhya Pradesh, Chhattisgarh and Goa
2.	Trade Marks Registry office, Ahmedabad	Gujarat, Rajasthan, of Daman, Diu, Dadra and Nagar Haveli
3.	Trade Marks Registry office, Kolkata	Arunachal Pradesh, Assam, Bihar, Jharkhand, Orissa, West Bengal, Manipur, Mizoram, Meghalaya, Sikkim, Tripura, Nagaland, Andaman & Nikobar Islands
4.	Trade Marks Registry office, New Delhi	Jammu & Kashmir, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Delhi and Chandigarh.
5.	Trade Marks Registry office, Chennai	Andhra Pradesh, Kerala, Tamil Nadu, Karnataka Pondicherry and Lakshadweep Island.

- **GI Office**

  The provision was the chief component of the GI Goods Act, 1999, and administered by the office of the GI Registry in Chennai, Tamil Nadu.

- **RGNIIPM**

  Provide training, management, research, education in the field of IPR. Rajiv Gandhi National Institute of Intellectual Property Management (RGNIIPM). This institute has been established as a national "Centre of Excellence" for training, management, research, education in the field of IPR, in Nagpur. Additionally, the institute addresses the need of increasing the general awareness and understanding of the government officers and users of IP systems in universities and other educational institutions.

- **Copyrights Office**

  It provides a legal method that safeguards an individual's original or innovative work by providing formal proof of ownership

Intellectual Property Management Process

Intellectual Property Management process is defined as strategic & systematic handling of intellectual properties in the institutions or organizations engaged in the creation and commercialisation of ideas, inventions, designs, symbols, names, images etc.

Source: https://www.g2.com/articles/intellectual-property-management

Steps in Intellectual Property process

1. Develop an IP strategy

An effective IP strategy must be developed to identify assets, understand competitors' assets and strategies and focus on the protection, enforcement and management of these assets.

There are four basic IP strategies that organizations can adopt to suit their business objectives:

- **Risk minimization:** Building a diverse IP portfolio and engaging in cross-licensing to reduce risks.
- **Cost reduction:** Maintaining assets and their effectiveness by cutting unnecessary costs.
- **Value approach:** Seeking to profit directly by leveraging intellectual property.
- **Tactical approach:** Focusing on research and development (R&D) activities and rethinking existing partnerships.

2. Implement a strategy for better decision-making

- Once the IP strategy is developed, it must be implemented to clarify the value of assets and achieve the desired outcomes. Generating and retaining profits from IP requires careful deliberation and collaboration between asset creators and business leaders.

3. Create frameworks and policies

- Formulate frameworks by creating IP management teams, educating employees about intellectual property, and communicating IP policies along with a clear plan of action for their implementation.
- Develop structures for IP licenses, contracts, and related agreements to ensure smooth management.

4. Administer and conduct negotiations

- IP legal service providers play an integral role in managing assets.
- Experts and commercial partners assist in administering relevant agreements and conducting necessary negotiations.

5. Understand IP rights and infringements

Intellectual property is essential for a business as it acts as a means to recognize, support, and promote the company's products and culture. Protecting intangible ideas and assets is imperative for extracting value and encouraging investment in innovation and creativity.

Infringement Management

Infringement is defined as an unauthorized use of protected material under IP laws. IPR infringement refers to the unauthorized use, duplication, or sale of materials or products that are legally regarded as protected intellectual property.

Types of infringement

i. Copyright infringement
ii. Patent infringement
iii. Trademark infringement
iv. Design infringement

Steps for Addressing IP Management and Infringement

1. **Preventive Measures:**

a) **IP Protection**: Obtain appropriate protections, such as patents, trademarks, copyrights, and trade secrets, to establish legal rights over IP assets.

b) **Contracts and Agreements**: Use contracts, licensing agreements, and non-disclosure agreements (NDAs) to define rights, permissions, and restrictions for third-party usage of IP assets.

c) **Employee Education**: Train employees on the importance of IP protection, confidentiality, and compliance with relevant laws and policies to minimize the risk of unintentional infringement.

d) **IP Audits**: Conduct regular audits to assess the status of IP assets, identify vulnerabilities, and ensure adherence to legal requirements and best practices.

2. Detection and Monitoring:

a) **Market Monitoring**: Monitor markets, competitors, and online platforms to detect potential infringement, counterfeiting, or unauthorized use of IP assets.

b) **Technology Tools**: Utilize advanced tools, such as web crawlers, image recognition software, and data analytics, to detect and track IP infringement across digital channels.

3. Enforcement and Remedial Actions

a) **Cease-and-Desist Letters**: Issue formal letters to alleged infringers, demanding the immediate cessation of infringing activities and adherence to IP rights.

b) **Alternative Dispute Resolution (ADR)**: Utilize mechanisms like mediation or arbitration to resolve IP disputes amicably and cost-effectively.

c) **Litigation**: Initiate legal proceedings, such as civil lawsuits, to enforce IP rights, seek injunctive relief, and claim damages or other remedies for infringement.

d) **Digital Takedown Requests**: Submit takedown requests to online platforms, search engines, and social media networks to remove infringing content.

4. Post-Infringement Measures

a) **Monitoring Compliance**: Continuously monitor compliance with settlement agreements to ensure infringing activities cease and that IP rights are respected.

b) **Recovery of Damages**: Pursue legal remedies to recover damages or other compensation resulting from infringement through court judgments or settlement agreements.

References

Intellectual Property: A Primer for Academia https://dst.gov.in/sites/default/files/E-BOOK%20IPR.pdf

https://pib.gov.in/newsite/PrintRelease.aspx?relid=142143

https://ipindia.gov.in/writereaddata/images/pdf/office-of-cgpdtm.pdf

https://www.academia.edu/105368143/Intellectual_Property_Rights_2 https://clarivate.com/intellectual-property/webinars/ip-forum-2023-empowering-the-ip-ecosystem

https://www.upcounsel.com/ipr-infringement

https://aishwaryasandeep.in/government-schemes-under-intellectual-property-rights

https://www.g2.com/articles/intellectual-property-management

http://www.ipindia.nic.in/about-us-rg.htm

https://www.ipindia.gov.in/writereaddata/Portal/Images/pdf/4__1___b___i__ii__iii__iv__Organizational_Structure_of_office_of_CGPDTM.pdf

https://ipindia.gov.in/writereaddata/images/pdf/office-of-cgpdtm.pdf

Volume: 04 Issue No: 12

ORGANIC BEAUTY - JAMUN LIP BALM

Article ID: AG-VO4-I12-52

***R. Sridharshini[1], T. Indhumathi[2], K. Meenaa[3] and E. Vidhya[4]**

[1] - Assistant Professor, Department of Agricultural Engineering, Nandha Engineering College (Autonomous), Erode, Tamil Nadu, India.

2,3,4 - UG Students, Department of Agricultural Engineering, Nandha Engineering College (Autonomous), Erode, Tamil Nadu, India.

*Corresponding Author Email ID: sridharshinir7@gmail.com

Abstract

Jamun Lip Balm is a natural lip care product infused with the powerful benefits of Jamun (black plum) extract. Rich in antioxidants, Vitamin C, and essential minerals, it nourishes and hydrates dry, cracked lips, promoting smoothness and elasticity. The balm's antibacterial and anti-inflammatory properties help soothe irritated lips, while its vitamin A content supports skin repair. Jamun's natural sugars enhance moisture retention, preventing dehydration. This product aligns with the growing consumer preference for organic, plant-based skincare, creating employment opportunities in the natural beauty industry. As demand for sustainable beauty products rises, Jamun Lip Balm offers potential for manufacturers and entrepreneurs.

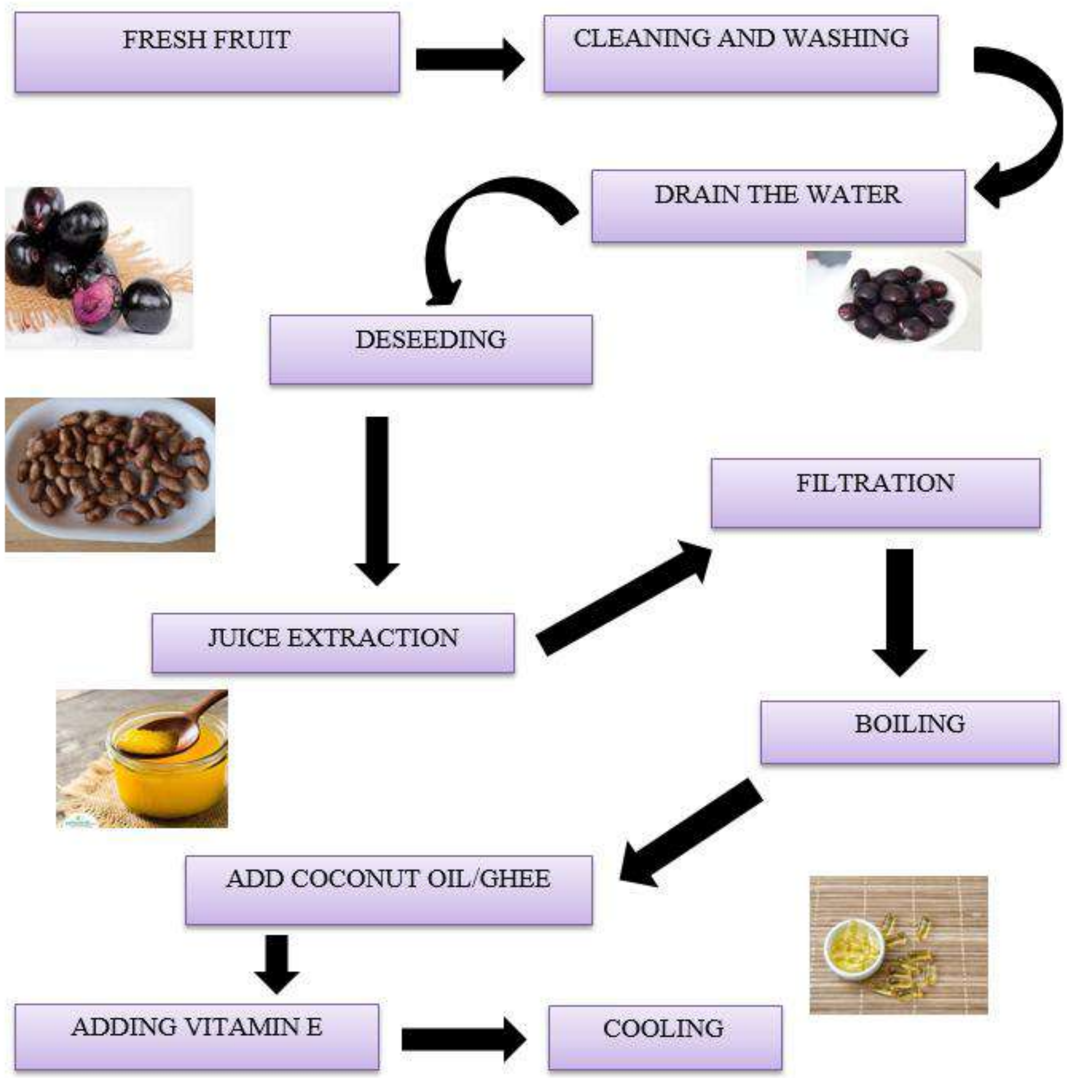
Keywords: Jamun, antioxidants, hydration, skincare, employability

Introduction

Presenting our Jamun Lip Balm, a revitalizing, natural balm that hydrates, shields and calms your lips. This lip balm provides a sensual, moisturizing experience while maintaining the natural hydration and softness of your lips. It is infused with the benefits of Jamun (Indian Blackberry), a fruit known for its abundance of vitamins and antioxidants. Jamun is well-known for its skin-rejuvenating qualities due to its high vitamin C concentration, which helps shield your lips' sensitive skin from drying out and chapping. All day long, your lips will feel smooth and healthy thanks to the protective barrier that the nourishing oils in this balm provide**.** Our

Jamun Lip Balm is your go-to natural lip care product whether you're fighting the harsh winter winds or simply need a daily lip care solution. Allow the antioxidant-rich jamun to give your lips the attention they so well deserve as you embrace the power of nature! Jamun plum lip balm, enriched with the natural goodness of Java plum (jamun), is a unique blend of nourishment and indulgence for your lips. Known for its antioxidant and hydrating properties, Jamun plum extract helps repair dry, chapped lips while protecting them from environmental damage. This lip balm provides a rich, glossy texture that locks in moisture and leaves your lips feeling soft, supple, and rejuvenated. Perfect for all seasons, it combines the fruity aroma of Jamun plum with a natural tint, offering a soothing and refreshing experience.

LIP BALM PROCESSING



JAMUN EXTRACTION AND PREPARATION

1. **Sourcing Ingredients**

Finding all required ingredients is the initial step. Beeswax, essential oils, vitamin E, and carrier oils (such as coconut or almond oil) are required for making Jamun Lip Balm. The secret to guaranteeing a superb product is using natural ingredients of the highest caliber.

2. **Making Jamun Extract**

You must squeeze out the juice and strain out any seeds or solids if you are using fresh jamun. This step can be omitted if you're using jamun powder or an extract.

3. **Blending and Melting Base Ingredients**

First, carrier oils (coconut, shea butter, etc.) must be added to melted beeswax in a double boiler. Mix this mixture until it's well blended. This forms the lip balm's basis.

4. **Blending and Mixing**

Make sure all the components are uniformly distributed by giving everything a good stir. This is crucial for the finished product's homogeneity and consistency.

1. **Cooling and Setting**

Transfer the blend into the appropriate receptacles (such jars, tins, or lip balm tubes) and let it cool and solidify at room temperature. This could take an hour or thirty minutes.

2. **Testing and Quality Control**

After the balm has set, you should check its consistency, texture, and aroma. Examine the balm for any flaws, such as uneven texture or ingredient separation.

Nutritional Benefits

Physical and Botanical Features

An evergreen tree that grows well in tropical and subtropical regions is the Java plum. It has glossy, dark green foliage and tiny, fragrant blooms, and it can reach a height of 30 meters. When ripe, the oval or oblong fruit turns dark purple to black. A unique combination of sweet, tart, and mildly astringent qualities may be found in its juicy, soft pulp.

Advantages of Nutrition

The Java plum is a nutrient-dense powerhouse. It is abundant in:

Vitamins: Rich in antioxidants, including vitamin C.

Minerals: Rich in calcium, iron, and potassium.

Dietary fiber helps maintain a healthy digestive system.

It is perfect for diabetics because of its low glycemic index.

Therapeutic Qualities

For generations, traditional medicine has made use of the Java plum's fruit, seeds, bark, and leaves. Among the noteworthy health advantages are:

- Diabetes Control: Blood sugar levels are known to be regulated by the seeds.
- Digestive Aid: The fruit's astringent qualities aid in the fight against dysentery and diarrhea.
- Antioxidant Boost: Fortifies the immune system and guards against cellular damage.
- Heart Health: A high potassium intake promotes heart health.
- Moisturizes and Hydrates: Natural sugars and moisturizing substances found in jamun aid to keep lips hydrated and supple, avoiding dryness or chapping.
- Combats Pigmentation of the Lips: Dark lips can be lightened with the use of jamun's natural components. The antioxidants support a more even skin tone on your lips and lessen the appearance of discoloration.

PHYSICAL TEST FOR LIP BALM

1. **Appearance Test**: Goal: To make sure the lip balm looks uniformly smooth.

How to Test: Examine the lip balm visually to ensure that its color, texture, and finish are consistent. Make sure the ingredients are not separated, have lumps, or have air bubbles.

2. **Texture Test**: Goal: To assess the balm's spreadability and smoothness on the lips.

How to Test: Put a tiny bit of lip balm on your lips or finger, then measure how readily it spreads. It should apply smoothly and not feel overly dry or greasy.

3. **Consistency (Hardness) Test**: Goal: To determine how soft or firm the lip balm is.

Method of Testing: Gently press your finger into the lip balm and watch how it reacts. It shouldn't be too hard (hard to apply) or too soft (melts too easily).

4. **Melting Point Test**: It is to make sure the lip balm doesn't melt too quickly in hot weather.

Test Procedure: Put a tiny sample of the lip balm in a warm, controlled environment (such as 40–50°C/104–122°F) and watch how it changes over time. Another way to test is to heat the balm slowly and see how it melts.

5**. pH Test**: The purpose of the optional pH test is to determine the balm's acidity or alkalinity and make sure it is safe and mild enough to apply to the lips.

Methods for Testing: To determine the balm's pH level, use pH strips. Lip balms should have a pH between 4.5 and 7.0 to avoid being overly alkaline or acidic.

Medical Benefits of Jamun Seeds:

The fruit of the Eugenia jambolana tree yields jamun seeds, which have a variety of therapeutic uses. Jamun seeds, which are high in flavonoids, alkaloids, and antioxidants, have long been utilized in Ayurvedic medicine to treat a variety of illnesses. It has been demonstrated that the seeds contain anti-diabetic qualities, assisting in blood sugar regulation and enhancing insulin sensitivity. Furthermore, it has been shown that jamun seeds contain anti-inflammatory, antibacterial, and antifungal properties, which makes them useful in the treatment of skin conditions, respiratory infections, and digestive issues. Additionally, the seeds have long been utilized to lower the risk of cancer, improve cardiovascular health, and enhance general well-being.

Medicinal Benefits of Jamun Fruit:

Jamun fruit has several health benefits and is a nutritional and medicinal powerhouse. Jamun fruit, which is high in flavonoids, phenolic acids, and antioxidants, helps control blood sugar levels, enhance insulin sensitivity, and avoid problems from diabetes. The fruit's anti-inflammatory qualities also make it a useful treatment for skin ailments, respiratory problems, and digestive difficulties. Jamun fruit has also been shown to support healthy liver and kidney function, prevent cardiovascular disease, and have anti-cancer qualities. The fruit is also useful in treating oral health conditions like mouth ulcers and gum inflammation because of its antibacterial and antifungal qualities. All things considered, jamun fruit is a safe and efficient means of enhancing general health and wellbeing.

Employability:

1. **Innovation:** By fusing ancient wisdom with contemporary skincare science, a novel lip balm formula was created using jamun extract.
2. **Problem-Solving:** Addressed consumer concerns around chemical-based goods by identifying the need for a sustainable, natural, and effective lip balm solution.
3. **Creativity:** Developed a striking packaging and branding that highlights the advantages and natural components of the product.
4. **Communication:** Highlighted the product's unique selling qualities through influencer relationships, social media, and in-store promotions.
5. **Teamwork:** To get the product to market, a group of professionals worked together, including skincare formulators, package designers, and marketing experts.
6. **Leadership:** Took the initiative to encourage eco-friendly and sustainable practices in the skincare industry, encouraging others to do the same.

Career Benefits:

1. **Product Development:** Acquired expertise in creating a distinctive skincare product from conception to launch.
2. **Marketing and Branding:** Acquired abilities in developing successful marketing campaigns and establishing a strong brand identity.
3. **Team Management:** Proven capacity to work with cross-functional teams and oversee numerous stakeholders.
4. **Sustainability and Social Responsibility:** Exhibited dedication to sustainable and sustainable practices in the skincare sector.

Conclusion

Jamun Lip Balm offers a natural and effective solution for keeping your lips soft, smooth, and well-moisturized. Packed with the nourishing benefits of jamun (black plum) fruit extract, it provides antioxidant protection, helps to prevent dryness, and promotes overall lip health. The balm's rich formulation, including essential vitamins, is ideal for combating chapped lips, especially during harsh weather conditions. Its gentle, fruity fragrance adds a refreshing touch, making it a delightful addition to your skincare routine. Overall, Jamun Lip Balm is a highly beneficial and soothing product for anyone seeking a natural way to care for their lips.

Volume: 04 Issue No: 12

THE FARMING FRIEND: A PORTABLE HANDHELD ONION TRANSPLANTER

Article ID: AG-V04-I12-53

***Dr.D.Ambika[1], S.Priya dharshini[2], S.Sasi kumar[3], P.Sujin[4] and B.Swethabala[5]**

1 - Associate professor, Department of Agricultural Engineering,

Nandha Engineering College (Autonomous), Erode, Tamil Nadu, India.

2,3,4,5 - UG Students ,Department of Agricultural Engineering,

Nandha Engineering College (Autonomous), Erode, Tamil Nadu, India.

*Corresponding Author Email ID: ambika.d@nandhaengg.org

Introduction

Onion (Allium cepa L.) is one of the major vegetable crop grown throughout the country. It is widely grownin different parts of the country mainly by small and marginal farmers.The handheld onion transplanter is an essential instrument that revolutionizes the way small-scale farmers farm. This innovative device is set at par with its effectiveness and simplicity. It features a spring-loaded jaw mechanism, with which holes can easily be punched into the soil or through mulch films. Activating a lever makes creating the ideal environment for seedlings a possibility, with this device ensuring they are firmly planted and covered with soil via its earthing mechanism.

One of the strengths of the handheld onion transplanter is that it is uniform in depth and spacing, which are essential points for uniform growth of crops as well as optimal yield. The ergonomic design of the transplanter reduces physical strain, allowing it to be used for extended periods, and minimizes fatigue-a great advantage over traditional manual planting methods. Further, the cost-effectiveness of this innovation also makes it easily accessible for resource-poor farmers, who still receive a sensible solution that neither compromises on efficiency nor on quality.

This onion transplanter adaptable to different soil conditions, farm environments will be easy to maintain as it is portable. Farmers can easily transport these across different fields. As an essential ingredient of modern agricultural tools, the handheld onion transplanter stands out as a perfect blend of innovative functionality and practicality in support of the sustainability of farming operations, ultimately enhancing productivity and profitability in onion cultivation.

Figure 1. Onion Cultivation

PROBLEM ANALYSIS:

FEEDBACK FROM FARMERS

Farmers have provided valuable feedback on the onion dippler, highlighting both its benefits and areas for improvement. Many farmers appreciate the device's ability to efficiently plant onion seedlings, which helps save time and labor. The hole-punching mechanism is also particularly commended for its effectiveness in ensuring proper planting depth since it makes a tapered hole in the soil to accommodate seedling placement. Few users have complained about the complexity of using device skill for the operator to ensure good and uniform planting depth. Differences in planting depth will lead to uneven growth and yields of crops. More so, there exist abrasion concerns of the punching mechanism, particularly when used on harder soil types.

IDENTIFICATION OF PROBLEM

Problems stemming from the use of onion dibblers are identified in order to improve their design and functionality. Some of the common complaints raised among farmers based on field performance studies and farmers' comments include the following:

- **Depth in Planting**

Problem: The planting depth really depends on the skill of the operator resulting in variable seedling depths.

Impact: This may affect crop growth and yield variability.

- Hand-Operated

Problem: It has to be pressed forcefully in soil to punch and work the lever which is hard work and tiresome.

Impact: This can limit the efficiency and speed of planting, especially in big fields.

- Durability and Maintenance:

Problem: The jaws as well as other mechanical parts may wear out quicker, especially in hard or rocky soils.

Impact: More time is consumed in maintenance and replacement of parts and increases operational costs as well as downtime

- Soil Conditions:

Problem: The device may not be effective on all soils, especially in compacted or heavy clay soils.

Impact: Poor performance on certain soils may limit the overall efficiency and reliability of the device.

- Row and Plant Spacing:

Problem: Consistent spacing among the rows and plants of most crops is not easily managed by a human.

Impact: Non-uniform spacing would influence crop density and total yield.

TYPES OF ONION FEEDER

- Handheld onion planter
- Mechanical onion planter
- Two-row onion planter
- Precision planter
- Paperpot transplanter
- Vertical onion planter

HANDHELD ONION PLANTER

A handheld onion planter is one of the pr practical agriculture tools, devised to make the process of planting onion seedlings easier and faster. This tool functions on a simple mechanism: spring-loaded jaws punch holes into the soil or plastic mulch film. The holes or gaps prepared by this action are tapered to facilitate seedling-planting by the user, who exerts the effort to push the planter into the ground and then releases the lever to open the jaws.

WORKING PRINCIPLE

The working principle of a handheld onion planter works on a simple yet practical mechanism with the purpose of making the planting process easier. This device is provided with a pair of springloaded jaws at its lower end, able to penetrate the soil or plastic mulch film and create a tapered hole for seedling placement. The planter is pushed into the soil and a lever automatically turns upward. The jaws open up to form the planting hole, and an acute seedling guide mechanism pushes the seedling into the hole with zero error. Once in place, an earthing mechanism covers it again with soil, solidly planting the seedling into the ground. This process allows for consistent planting depth and spacing, which enhances crop uniformity and overall yield.The handheld design, via ergonomic optimization, reduces the physical strain on the user to enable long-term usage, ideal for small-scale farmers, as it will be inexpensive and easier to save time in planting onion seedlings. The simplicity and portability of the handheld planter mean that it is adaptable for so many varied soil conditions; therefore, it does improve planting practices and increases productivity.

USES

The small onion planter machine really benefits the small to medium-scale farmer. Some of its major usages and benefits follow:

- Increased Planting Efficiency

Benefit: The planters for small onions would do the planting automatically and save time and labor regarding placing the onions.

Impact: The outcome is faster planting. More area is covered within a lesser number of days if planted by this machine, as opposed to manual planting.

- Uniform spacing and depth of planting:

Benefit: These machines ensure that each onion seedling is planted at a consistent depth and spacing.

Impact: Consistent planting depth and spacing improve crop uniformity, leading to better growth and higher yields.

- Reduced Labor Cost:

Benefit: By automating the planting process, farmers can reduce the need for manual labor.

Impact: This lowers labor costs, making the planting process more economical.

- Less Physical Strain:

Benefit: Planter machine reduces physical labour load that is related to the process of manual planting.

Impact: The whole process is less tiring and more easy on people, especially the aged or physically handicapped farmers.

- High Precision:

Benefit: Small planters are precision planters with minimum seedling damage and maximize placement

Impact: Better seedling establishment and increased overall productivity.

- Adaptability to Conditions:

Benefit: Large numbers of small onion planters are adjustable for different soil conditions and types of mulch.

Impact: Such versatility allows for very efficient planting in a variety of settings, enhancing versatility.

- Cost-Effectiveness for Small Farms:

Benefit: Small onion planters are generally more affordable than larger, more complex machines.

Impact: This makes it accessible investment for small-scale farmers looking to upgrade their operations.

- Time-Saving:

Benefit: These machines drastically reduce the time taken for planting.

Impact: Farmers can save valuable time that can be utilized for other farming activities or for increasing the scale of planting operations.

BENEFITS

The handheld onion planter is capable of improving the whole planting process for farmers as it offers a range of benefits. The principal advantage is that it makes planting very efficient in creating holes for seedlings, increasing speed and reducing the time required compared with most traditional methods of planting. The tool ensures planting depth and spacing are uniform, which is important for crop growth and a better yield. This ergonomic design reduces the physical strain from the user, making it possible to operate for quite a period without feeling fatigued or having the risk of injury. Moreover, the handheld onion planter is cost-effective. It offers an affordable option to small-scale farmers who cannot afford heavy machinery equipment that costs significantly more. Being simple to use and maintain means fewer breakdowns, thus few occasions for the farmers to incur further costs in terms of money and time. In addition, the farmer's portability and adaptability to different soil conditions make it versatile and practical for different farming environments. Overall, the handheld onion planter is a valuable tool that helps farmers improve planting efficiency, reduce labor costs, and increase crop productivity, hence turning into one of the essential assets of modern agriculture.

Conclusion

Greatly enhanced version of agricultural tools aimed for onion planting in a more efficient and effective manner. Simple, robust mechanism that is precise in planting with much reduced labor intensity and time spent as would be the case with manual planting. Uniform growth and maximum crop yield are given priority by an assurance of consistent planting depth and spacing. Ergonomic design decreases the physical strain of user, hence applicable for prolonged use and increases the overall efficiency of planting. Inexpensive, it is an accessible tool for small and medium-scale farmers who can easily employ and maintain it. Flexibility of the planter for implementing it in different soil conditions and its ability to move around further make it useful in different farmlands. Practical solution for modernizing the ancient way of planting. Supports sustainable agriculture with increased productivity and profitability for farmers.

References

Rasool, K., Islam, M.N., Ali, M., Jang, B.E., Khan, N.A., Chowdhury, M., Chung, S.O. and Kwon, H.J., 2020. Onion transplanting mechanisms: A review. *Precis. Agric. Sci. Technol*, *2*, p.196.

Khadatkar, A., Mathur, S.M. and Gaikwad, B.B., 2018. Automation in transplanting. *Current science*, *115*(10), pp.1884-1892.

Reza MN, Ali M, Habineza E, Kabir MS, Kabir MS, Lim SJ, Choi IS, Chung SO. Analysis of operating speed and power consumption of a gear-driven rotary planting mechanism for a 12-kW six-row self-propelled onion transplanter. Spanish Journal of Agricultural Research. 2023 Jul 12;21(3):e0207.

Sharma, A. and Khar, S., 2022. Current developments in vegetable transplanters in developing countries: a comprehensive review. *International Journal of Vegetable Science*, *28*(5), pp.417-440.

Sharma, Ankit, and Sanjay Khar. "Current developments in vegetable transplanters in developing countries: a comprehensive review." *International Journal of Vegetable Science* 28, no. 5 (2022): 417-440.

Sharma, A. and Khar, S., 2022. Current developments in vegetable transplanters in developing countries: a comprehensive review. *International Journal of Vegetable Science*, *28*(5), pp.417-440.

Volume: 04 Issue No: 12

NEW GENERATION HERBICIDES AND CONO WEEDING: A POWERFUL DUO FOR DIRECT SEEDED RICE

Article ID: AG-V04-I12-54

B. Jothilakshmi*[1] and S.M. Suresh Kumar[2]

[1]PG Scholar, Department of Agronomy, Faculty of Agriculture, Annamalai University, Chidambaram - 608 002, Tamil Nadu, India.

[2] Associate Professor, Department of Agronomy, Rice Research Station (TNAU), Tirur - 602025, Tamil Nadu, India.

*Corresponding Author Email ID: jothiviji07@gmail.com

Introduction

Direct-seeded rice (DSR) is a promising cultivation method that offers numerous advantages in terms of efficiency and resource management, including reduced labour costs, water savings, and potential for increased yield. However, managing weeds effectively remains a major challenge within DSR systems. Weeds can notably diminish crop productivity by competing for essential resources like water, nutrients, and sunlight. To address this issue, , it is crucial to implement integrated weed management approaches. This study explores the efficacy of combining chemical and mechanical weed control methods to optimize weed management and enhance rice yield in DSR.

MATERIALS AND METHODS

The experiment was laid out in randomized block design with nine treatments and replicated thrice. The treatments comprised of different weed management practices, *viz.*, T_1 - Unweeded control, T_2 - Twice hand weeding on 20 and 40 DAS, T_3 - Twice cono weeding on 20 and 40 DAS, T_4 -Pre emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 10 kg ha^{-1} on 7 DAS *fb* hand weeding on 40 DAS, T_5 -Pre emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 10 kg ha^{-1} on 7 DAS *fb* cono weeding on 40 DAS, T_6 - Early post emergence application of triafamone 20% + ethoxysulfuron 10 % WG @ 225 g ha^{-1} on 12 DAS *fb* hand weeding on 40 DAS, T_7 - Early post emergence application of triafamone 20% + ethoxysulfuron 10% WG @ 225 g ha^{-1} on 12 DAS *fb* cono weeding on 40 DAS, T_8 - Post emergence application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 20 DAS *fb* hand weeding on 40 DAS, T_9 - Post emergence application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 20 DAS *fb* cono weeding on 40 DAS.

RESULTS

The experimental results of the present study revealed that all the treatments significantly influenced the weed biometrics, growth parameters, yield attributes and yield of rice. Among the weed management practices, pre emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 10 kg ha^{-1} on 7 DAS *fb* hand weeding on 40 DAS (T_4) registered a greater degree of efficiency (86.19 and 81.68 per cent at 30 and 60 DAS, respectively) in controlling a diverse weed flora, decreased the total number of weeds, lowered the production of weed dry matter and less nutrient uptake by weeds in direct seeded rice and also recorded the higher growth attributes, *viz.*, plant height (105.14 cm), number of tillers hill^{-1} (12.56), leaf area index (5.79), crop dry matter production (11935 kg ha^{-1}) and the yield components, *viz*., number of productive tillers (362.13) and filled grains per panicle (108.76), grain yield (5304 kg ha^{-1}) and straw yield (7550 kg ha^{-1}). This was followed by pre emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 10 kg ha^{-1} on 7 DAS *fb* cono weeding on 40 DAS (T_5) which was on par with early post emergence application of triafamone 20% + ethoxysulfuron 10 % WG @ 225 g ha^{-1} on 12 DAS *fb* hand weeding on 40 DAS (T_6). The maximum B:C ratio of 2.62 was recorded with application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 10 kg ha^{-1} on 7 DAS *fb* cono weeding on 40 DAS (T_5) which highlights the economic viability of integrating pre emergence herbicides with cono weeding. The higher weed population, weed dry matter production, the lower growth, yield attributes and yield of rice, the lowest net income and B:C ratio was recorded in unweeded control (T_1).

Conclusion

Based on the results, efficient and economic weed management could be achieved by pre emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 10 kg ha^{-1} on 7 DAS *fb* cono weeding on 40 DAS (T_5) in direct seeded rice. Hence, this method of weed management can be recommended to attain sustainable agricultural productivity and financial gains in direct seeded rice cultivation.

Volume: 04 Issue No: 12

LACTIC ACID BACTERIA AS A BIOCONTROL AGENT FOR ROOT-KNOT NEMATODES

Article ID: AG-V04-I12-55

***Poorniammal, R[1] and S.Prabhu, S[2]**

[1]Dept of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore, India [2]Dept of Plant Protection, Horticultural College and Research Institute, TNAU, Periyakulam, Tamil Nadu, India

*Corresponding Author Email ID: r.poornii@tnau.ac.in

Abstract

Root-knot nematodes (*Meloidogyne* spp.) are among the most destructive plant-parasitic nematodes, causing significant yield losses in various crops worldwide. Lactic acid bacteria (LAB), known for their antimicrobial properties and safe application, have emerged as a promising biocontrol agent against these pests. LAB exert their effects through multiple mechanisms, including the production of organic acids, antimicrobial compounds, and bioactive metabolites that disrupt nematode survival and reproduction. Additionally, LAB enhance plant defense through induced systemic resistance and improve soil health by promoting beneficial microbial communities. Studies have demonstrated the efficacy of LAB in reducing nematode populations, mitigating root damage, and improving plant growth parameters in crops such as tomato, cucumber, and banana. Their eco-friendly nature, cost-effectiveness, and compatibility with integrated pest management (IPM) strategies make LAB a sustainable alternative to chemical nematicides. This paper explores the potential of LAB as biocontrol agents, highlighting their mechanisms of action, application methods, and advantages, while addressing the challenges and future prospects of their use in sustainable agriculture.

Keywords: Biocontrol; Lactic acid bacteria; Mechanism; Root-knot nematodes

Introduction

Root-knot nematodes (*Meloidogyne* spp.) are among the most damaging plant-parasitic nematodes, affecting a wide range of crops worldwide. They attack plant roots, causing galls, reduced nutrient and water uptake, stunted growth, and significant yield losses. The increasing demand for sustainable and environmentally friendly pest management solutions has led to the exploration of microbial biocontrol agents, including lactic acid bacteria (LAB), as potential alternatives to chemical nematicides.

Biological control is a safe way to control pests and pathogens. However, antagonists and nematophagous microorganisms are the best potential substitutes for chemical nematicides. The performance of bioagents under polyhouse conditions is very poor. Rhizobacteria refer to those bacteria that are capable of colonizing the rhizosphere aggressively. Aerobic endospore forming bacteria, mostly *Bacillus* spp. are among the prevailing populations, which inhabit the rhizosphere and are able to antagonize PPN (Jaffar et al. 2023).

Greatest reduction in soil nematode populations was found in the presence of both pathogens nematode and fungus followed by nematode alone. All the used bioagents in this study significantly reduced the fungal incidence in cucumber as compared to non-treated inoculated check. Lesser (10 %) fungal disease incidence was observed with the bioagents liquid formulations as compared to nontreated inoculated check followed by *T. viride* (15 %) where both the pathogens inoculated simultaneously. These findings were also agreements with the studies of Druzhinina et al. (2011).

Lactic acid bacteria (LAB) have traditionally been used to ferment carbohydrate-rich foods. LAB are known to improve the nutritional value of foods and control human intestinal infections. Lactic acid bacteria are a group of gram-positive, non-sporulating microorganisms known for their ability to produce lactic acid as a major metabolic byproduct. Common genera of LAB include *Lactobacillus*, *Lactococcus*, *Pediococcus*, *Enterococcus*, and *Streptococcus*. These bacteria are widely used in food fermentation due to their antimicrobial properties and are considered safe for use in agricultural applications. LAB have gained attention as biocontrol agents due to their ability to inhibit plant pathogens through multiple mechanisms.

They also have an antagonistic activity against pathogenic bacteria and fungi, which makes them ideal for developing biocontrol agents for use on plants. For these reasons, LAB is currently attracting much attention in the agricultural industry as alternatives to chemical pesticides, which are associated with problems such as antibiotic resistance and pesticide residue. *Lactobacillus* species has been known to function as an antagonistic agent and exhibit antimicrobial activity.

Several compounds produced by LAB, such as organic acids, hydrogen peroxide, bacteriocins, and fat and amino acid metabolites, are among the antimicrobial factors responsible for the competitive exclusion of plant pathogen. A little is known about the potential of *Lactobacillus* as a biocontrol agent against phytopathogens. Additionally, there are few reports on the nematicidal activity of LAB on phytopathogenic nematodes.

Mechanisms of LAB in Controlling Root-Knot Nematodes

1. **Production of Organic Acids**

   LAB produce organic acids such as lactic acid, acetic acid, and formic acid, which can reduce soil pH and create unfavorable conditions for nematode survival and reproduction. These acids may also directly disrupt the cuticle of nematodes, leading to their immobilization or death.

2. **Bacteriocins**

   Bacteriocins are ribosomally synthesized antimicrobial peptides produced by bacteria that can kill or inhibit the growth of related or unrelated bacterial strains without harming the producing bacteria (Yang et al., 2012). These peptides exhibit multiple antimicrobial mechanisms, including interference with cell wall synthesis, disruption of the cytoplasmic membrane, inhibition of protein synthesis, disruption of DNA replication and transcription, and hindrance of septum formation (Ahmad et al., 2017). Certain lactic acid bacteria (LAB) are known to produce bacteriocins and bacteriocin-like inhibitory substances (BLIS). Most LAB bacteriocins are either small, heat-stable peptides or larger, heat-sensitive proteins or complexes with antibacterial activity, while the producer cells remain immune to their own bacteriocins.

3. **Antimicrobial Metabolites**

   LAB secrete various antimicrobial compounds, including hydrogen peroxide, and fatty acids, which can suppress not only nematodes but also secondary soil pathogens like fungi and bacteria. This dual action makes LAB effective against nematode-associated disease complexes.

4. **Reuterin**

   Reuterin is a glycerol-derived antimicrobial compound produced by certain lactobacilli, with its production being directly or indirectly stimulated by the presence of glycerol under anaerobic conditions. It is a potent, broad-spectrum inhibitor that functions independently of pH and is resistant to degradation by proteolytic and lipolytic enzymes. Reuterin disrupts microbial activity by inhibiting DNA replication and has been shown to be effective against a wide range of pathogens, including yeasts, fungi, protozoa, and viruses.

5. **Induction of Systemic Resistance**

   LAB can stimulate plants to activate their natural defense mechanisms, a process known as induced systemic resistance (ISR). By enhancing the production of defense-related enzymes and secondary metabolites, LAB-treated plants can better resist nematode infection.

6. **Competition for nutrients**

   LAB compete with nematodes and other soil pathogens for nutrients and ecological niches, effectively reducing the survival and proliferation of these pests.

7. **Interruption of Nematode-Plant Interactions**

   Certain LAB strains produce bioactive compounds that interfere with the signaling pathways essential for nematode host recognition and penetration, thereby reducing infection rates.

Effect of LAB in Controlling Root-Knot Nematodes

Seo et al., (2019) explained Out of 237 bacterial strains tested, *Lactobacillus brevis* WiKim0069 exhibited the strongest nematicidal activity against second-stage juveniles (J2) of *Meloidogyne incognita*, *M. arenaria*, and *M. hapla*, as well as inhibited *M. incognita* egg hatching. Its culture filtrate, with a pH of 4.2, contained acetic acid (11,190 µg/ml), lactic acid (7,790 µg/ml), malic acid (470 µg/ml), and succinic acid (660 µg/ml), which collectively caused 98% J2 mortality at 1.25%. In pot experiments, the filtrate suppressed gall and egg mass formation on tomato roots in a dose-dependent manner and reduced gall formation on melon under field conditions, with 62.8% efficacy compared to 32.8% for fosthiazate. This study is the first to highlight the potential of kimchi-derived LAB for root-knot nematode management via organic acid production.

Organic acid-producing LAB from kimchi and evaluating their nematicidal activity. Among 234 isolates, *Lactiplantibacillus plantarum* WiKim0090 exhibited the highest nematicidal and egg hatch inhibitory activities, with nematode mortality reaching 100% at 2.5% culture filtrate and a 50% lethal concentration of 1.41%. In pot tests, a mixture of WiKim0090 and copper sulfate significantly suppressed gall formation, outperforming the commercial nematicide abamectin. The findings suggest that the WiKim0090-copper sulfate combination is a promising and effective method for controlling root-knot nematodes (Kim et al., 2022)

Conclusion

Lactic acid bacteria (LAB) can enhance crop production through various mechanisms, including acting as biocontrol agents (BCAs), improving nutrient availability, alleviating biotic and abiotic stresses, and directly stimulating plant growth. Their Generally Recognized As Safe (GRAS) status and extensive use in food research make them ideal candidates for crop protection. Despite their ubiquity in the phytomicrobiome, the potential of LAB as BCAs and plant growth promoters has largely been overlooked. Emerging evidence highlights their ability to serve as renewable and safe agricultural inputs, aiding in plant nematode control and growth enhancement. However, further research is needed to evaluate their biocontrol efficacy under field conditions and to optimize LAB bioproduction and formulation for agricultural applications.

References

Jaffar, N.S., Jawan, R., and Chong, K.P. (2023). The potential of lactic acid bacteria in mediating the control of plant diseases and plant growth stimulation in crop production - A mini review. *Frontiers in Plant Science*, 13,1047945.

Seo, H.J., Park, A.R., Kim, S., Yeon, J., Yu, N.H., Ha, S., Chang, J.Y., Park, H.W, Kim J.C. (2019).Biological Control of Root-Knot Nematodes by Organic Acid-Producing *Lactobacillus brevis* WiKim0069 Isolated from Kimchi. *Plant Pathology* Journal, 35(6):662-673.

Kim, S., Kim, H.M., Seo, H.J, Yeon, J., Park, A.R, Yu, N.H., Jeong, S.G., Chang, J.Y., Kim, J.C., Park, H.W. (2022). Root-Knot Nematode (*Meloidogyne incognita*) Control Using a Combination of *Lactiplantibacillus plantarum* WiKim0090 and Copper Sulfate. Journal of Microbiology and Biotechnology. 28;32(8):960-966.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

PADDY STUBBLE BURNING: THE HIDDEN ECONOMIC COSTS OF YIELD DECLINE AND SOIL DAMAGE

Article ID: AG-V04-I12-56

***CH. Shekhar and **Dr. D. Srinivasa Reddy**

*****Ph.D. Research Scholar, Department of Agricultural Economics, PJTAU, Telangana, India

******Scientist Field Officer, Cost of Cultivation Scheme, Agricultural Economics, PJTAU Telangana, India

*Corresponding Author Email ID: shekharagecon@gmail.com

Abstract

Paddy stubble burning, a widespread practice in agricultural regions of northern India, has long been criticized for its environmental and health implications. However, its hidden economic consequences on agricultural productivity, soil fertility, and farmers' livelihoods remain underexplored. This article delves into the economic toll of stubble burning, highlighting how it leads to soil degradation, declining crop yields, and increased dependency on costly chemical fertilizers. The practice also exacerbates air pollution, disrupting climatic conditions essential for farming, further compounding the economic losses. By examining the factors driving this practice, such as cost constraints and limited alternatives, this article underscores the urgency of adopting sustainable agricultural methods. It proposes solutions such as government subsidies for eco-friendly residue management tools, crop diversification, and farmer education to address the economic and environmental challenges posed by stubble burning. The findings emphasize that while stubble burning may offer short-term convenience, its long-term costs significantly outweigh its perceived benefits, threatening both agricultural sustainability and economic stability.

Key Words: Paddy stubble burning, Agricultural Productivity, Soil Fertility, Air pollution and Crop diversification.

Introduction

As the paddy harvesting season concludes in northern India, a dense layer of smog blankets the region, signaling the onset of paddy stubble burning. This practice, prevalent in states like Punjab, Haryana, and Uttar Pradesh, involves the deliberate burning of leftover crop residue to clear fields quickly for the next sowing cycle. While the environmental and health impacts of this practice are well-documented, its economic consequences remain a largely overlooked yet critical aspect.

Agriculture, the backbone of India's economy, contributes approximately 18% to the national GDP and employs nearly half of the country's workforce. However, practices like stubble burning are undermining the sector's sustainability. By depleting soil nutrients, destroying organic matter, and disrupting the balance of essential microorganisms, stubble burning poses a direct threat to soil health. This, in turn, reduces crop productivity and increases reliance on chemical fertilizers, escalating production costs for farmers. Over time, these hidden costs erode farmers' profits and weaken the agricultural sector's overall contribution to the economy.

The economic ramifications are not limited to the fields. The massive air pollution caused by stubble burning disrupts climatic conditions essential for farming, such as rainfall and temperature stability. It also worsens public health, increasing medical costs for rural and urban populations alike. These interconnected challenges create a cascading effect on the national economy, highlighting the urgency of addressing this issue comprehensively.

Despite its significant drawbacks, stubble burning persists due to economic and logistical constraints. The short window between the kharif and rabi cropping seasons leaves farmers with little choice but to resort to burning, as sustainable alternatives often require financial investments that many cannot afford. While government initiatives have introduced subsidies for residue management tools, their reach and effectiveness remain limited, leaving millions of farmers trapped in this damaging cycle.

This article aims to shed light on the economic costs of paddy stubble burning, focusing on its impact on soil degradation, crop yields, and the broader economy. By exploring the root causes and long-term consequences of this practice, it seeks to highlight the need for sustainable solutions. The article also proposes actionable strategies, including promoting affordable alternatives, incentivizing eco-friendly practices, and educating farmers on the economic risks of stubble burning. Ultimately, addressing this issue is not just about protecting the environment but also about safeguarding the livelihoods of millions of farmers and ensuring the stability of India's agricultural economy.

THE LINK BETWEEN STUBBLE BURNING AND SOIL HEALTH

Paddy stubble burning, while providing farmers with a quick and seemingly cost-effective way to clear fields for the next sowing season, comes with severe consequences for soil health. When crop residues are burned, the intense heat—often reaching temperatures of up to 600°C—destroys not just the stubble but also the organic matter and beneficial microorganisms present in the soil. These microorganisms play a critical role in maintaining soil fertility by breaking down organic material, enhancing nutrient availability, and improving soil structure. Their loss leaves the soil less capable of supporting healthy crop growth.

In addition to killing soil biota, the process of burning depletes the soil of essential nutrients. Nitrogen, phosphorus, and potassium—commonly known as NPK—are fundamental for crop productivity, and their depletion directly impacts the soil's capacity to sustain high yields. According to a study conducted by the Indian Council of Agricultural Research (ICAR), burning one ton of paddy residue leads to the loss of approximately 5.5 kilograms of nitrogen, 2.3 kilograms of phosphorus, and 25 kilograms of potassium per hectare. This is a significant loss, given that these nutrients are critical for plant growth: nitrogen supports vegetative growth, phosphorus aids in root development and energy transfer, and potassium enhances drought resistance and disease tolerance.

The damage doesn't end there. The loss of organic matter reduces the soil's water-holding capacity, making it less effective at retaining moisture. This is especially problematic in water-scarce regions like Punjab and Haryana, where groundwater levels are already critically low. Additionally, the barren topsoil becomes more prone to erosion, further exacerbating nutrient loss and land degradation.

As soil fertility declines, farmers are forced to compensate by applying larger quantities of chemical fertilizers. While this may temporarily sustain yields, it creates a new set of problems. Excessive fertilizer use can lead to soil salinization, reduced microbial diversity, and water contamination from runoff. Over time, the increased dependency on fertilizers not only raises production costs for farmers but also locks them into a cycle of declining soil health and diminishing returns.

This cycle of degradation poses a long-term threat to agricultural sustainability. Once the soil's natural fertility is depleted, restoring it is a slow and expensive process. Thus, while stubble burning may appear to be a cost-effective solution in the short term, its long-term economic and ecological costs are far greater, making it a destructive practice that undermines the very foundation of farming. Addressing this issue is critical for ensuring the long-term health of agricultural lands and the livelihoods of millions of farmers.

THE DOMINO EFFECT ON THE ECONOMY

The economic impact of stubble burning extends far beyond the confines of the agricultural fields. One of the most significant and visible consequences of this practice is the air pollution it generates, which blankets large parts of northern India in a thick, toxic smog every harvest season. This pollution has far-reaching implications, not just for public health but also for agriculture, climate stability, and economic productivity.

Air Pollution and Agriculture

When paddy stubble is burned, the resulting smoke releases large quantities of particulate matter (PM2.5 and PM10), carbon monoxide, methane, and other harmful gases into the atmosphere. These pollutants form a dense smog that lingers for weeks, reducing visibility and blocking sunlight. This reduction in sunlight affects photosynthesis, a process critical for crop growth. Studies suggest that diminished sunlight caused by smog can stunt crop development and lower agricultural productivity, compounding the already adverse effects of soil degradation. Furthermore, stubble burning contributes to climate change by releasing greenhouse gases such as carbon dioxide and methane. The cumulative impact of these emissions disrupts normal weather patterns, leading to erratic rainfall, unseasonal frosts, and extreme weather events such as droughts and floods. These climate anomalies pose a serious threat to agricultural stability, as they directly impact sowing and harvesting cycles. For farmers who are already struggling with shrinking yields and rising costs, these disruptions can lead to devastating financial losses.

Healthcare Costs and Productivity Losses

The ripple effects of stubble burning extend into the realm of public health, creating a significant economic burden. The toxic air produced during stubble burning exacerbates respiratory and cardiovascular diseases, particularly in densely populated areas like Delhi, Punjab, and Haryana. Vulnerable groups such as children, the elderly, and individuals with pre-existing conditions face heightened health risks.

A joint study by The Energy and Resources Institute (TERI) and the University of California highlights that the economic cost of air pollution in India could exceed $150 billion annually. A significant portion of this cost is attributed to healthcare expenditures, lost workdays, and reduced labor productivity caused by illnesses linked to poor air quality. In rural areas, where access to healthcare is limited, the impact is even more pronounced, forcing families to bear the brunt of out-of-pocket medical expenses.

The economic losses are not confined to individual households. Widespread health issues reduce workforce productivity, affecting sectors beyond agriculture. For instance, urban centers like Delhi, which suffer from severe pollution during stubble-burning season, experience disruptions in transportation, schooling, and business operations. These disruptions contribute to a broader economic slowdown, underscoring the interconnected nature of the problem.

Long-Term Economic and Environmental Costs

The environmental degradation caused by stubble burning also has long-term economic implications. Poor air quality accelerates the rate of climate change, leading to rising temperatures and an increased frequency of extreme weather events. These conditions pose a significant threat to India's predominantly agrarian economy, where a large portion of the population depends on stable weather patterns for their livelihoods.

Additionally, the financial burden of mitigating air pollution falls on government resources. Investments in air quality monitoring systems, healthcare infrastructure, and emergency measures to control pollution spikes require significant funding, diverting resources away from other critical areas of development.

Why Do Farmers Still Burn Stubble?

Farmers burn paddy stubble because it is the quickest and most cost-effective way to prepare their fields for the next crop. In northern India, the time window between the harvesting of paddy (rice) and the sowing of wheat is extremely short—usually only two to three weeks. During this period, farmers need to clear their fields of leftover straw, called stubble, so they can start planting the next crop on time. Burning the stubble is a fast process that requires minimal effort and resources compared to other methods.

However, sustainable alternatives to burning, such as using specialized machines like happy seeders or incorporating stubble into the soil using bio-decomposers, are often expensive. These machines involve high upfront costs and operational expenses, which most small and marginal farmers cannot afford. Even though the government provides subsidies to make such equipment more accessible, the distribution and implementation of these subsidies are often inefficient. Many farmers are unaware of these schemes, or they find the process to access the subsidies cumbersome and time-consuming.

In addition to financial constraints, the lack of proper infrastructure and logistical support also discourages farmers from adopting eco-friendly practices. For example, there are limited facilities for large-scale stubble collection and processing, such as turning it into biofuel, animal fodder, or compost. Without viable alternatives readily available, farmers feel they have no choice but to burn the residue to save time and money.

Moreover, awareness about the long-term negative impacts of stubble burning—such as soil degradation, air pollution, and reduced crop yields—is still low among many farming communities. Even when farmers understand the harmful effects, their immediate financial needs and time constraints often take priority over environmental considerations. As a result, stubble burning remains a widespread practice, driven by a combination of economic pressures, logistical challenges, and lack of awareness or support.

Breaking the Cycle: Solutions for Sustainable Agriculture

Addressing the economic impact of stubble burning requires a holistic and collaborative approach:

1. **Promoting Affordable Alternatives**: Governments must ensure that residue management equipment is affordable and accessible to all farmers. Expanding subsidy programs and improving distribution networks can encourage wider adoption of eco-friendly practices.
2. **Adopting Crop Diversification**: Reducing dependence on water-intensive paddy by promoting alternative crops such as millets and pulses can significantly lower the generation of stubble while ensuring sustainable land use.
3. **Encouraging Bio-Decomposers**: Innovative solutions like bio-decomposers, which convert crop residue into organic manure, can help address both soil health and waste management issues.
4. **Incentivizing Green Practices**: Farmers should be rewarded for adopting sustainable methods. Carbon credits or direct financial incentives could motivate them to move away from burning practices.

5. **Education and Awareness Campaigns**: Empowering farmers with knowledge about the long-term economic losses associated with stubble burning can drive behavioral change. Community-driven initiatives can also play a crucial role in fostering a sense of collective responsibility.

Conclusion

Paddy stubble burning is not just an environmental issue—it's an economic crisis in disguise. The short-term convenience it offers to farmers comes at the expense of soil fertility, crop yields, and financial sustainability. For a nation like India, where agriculture is the backbone of the economy, these hidden costs cannot be ignored. By investing in sustainable practices and addressing the economic constraints faced by farmers, India can pave the way for a greener, more prosperous future. The time to act is now—because the cost of inaction is a burden no one can afford to bear.

References

ICAR. (2018). *Impact of crop residue burning on soil health and agricultural productivity*. Indian Council of Agricultural Research.

PAU. (2017). *Long-term effects of paddy stubble burning on soil fertility and crop productivity*. Punjab Agricultural University.

CPCB. (2020). *Annual air quality report on stubble burning and its environmental consequences*. Central Pollution Control Board.

TERI & UC. (2019). *Economic cost of air pollution in India due to agricultural residue burning*. The Energy and Resources Institute & University of California.

Sikh Studies Research Foundation (SSRF). (2019). *Drivers of stubble burning in Punjab and Haryana: A socio-economic study*.

India Today. (2019). *Why farmers burn paddy stubble despite the costs*. India Today.

FAO. (2021). *Agro-ecological solutions for sustainable agriculture and stubble management in India*. Food and Agriculture Organization.

Punjab State Farmers' Commission. (2020). *Policy recommendations for sustainable agricultural practices and stubble burning reduction*. Punjab Government.

Singh, P., & Sharma, R. (2018). *Government policies and the future of stubble burning in India*. Economic and Political Weekly.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

INDIGO-A DUAL PURPOSE GREEN LEAF MANURE TREE

Article ID: AG-VO4-I12-57

[1]Arathi, J., [2*]V. Krishnan, V., [1]R. Praveen, [1]K. Preetha, [1]J, [1]S. Aparna and [1]S. Lashmipriya

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

Indigo tree, botanically called *Indigofera tinctoria* (2n: 16), belonging to sub family Papilionoideae, is a n important green leaf manure crop, commonly called true indigo, widely introduced and naturalized species in many tropical countries and southern tropical Africa, South-west islands of the Indian Ocean, India and Pakistan, China, Southeast Asia, Indonesia, Australia and the Pacific Islands and naturalized in Central and South America. This shrub was the original source of the blue dye known as indigo. The leaves of this plant contain indican. Dye is obtained by fermentation of the leaves which converts the indican into the blue dye indigotin.

BOTANICAL DESCRIPTION OF INDIGO TREE

Habitat: *Indigofera tinctoria* occurs in seasonally flooded grassy fields with scattered trees, and also in roadsides, bush margins, brushwood and secondary forest, and on riverbanks, cultivated grounds and sandy coasts.

Habit: It is an herbaceous, annual, biennial or perennial plant, with a small bushy shrub, 60 to 120 cm tall. Annual to perennial herb or subshrub up to 2 m tall.

Root: Tap root system with root nodules

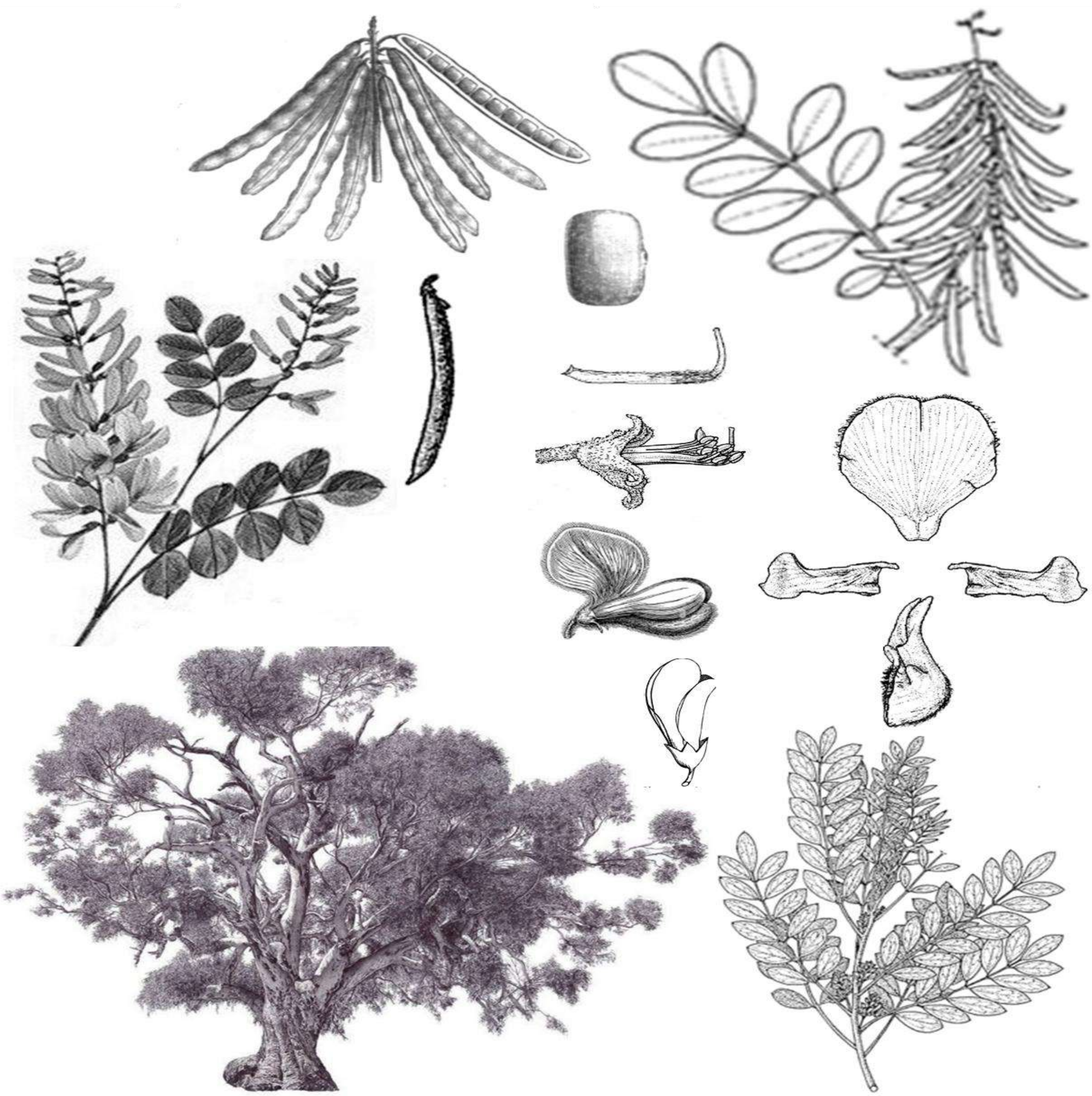
Stem: Cylindrical, full, erect, more or less woody at the base, abundantly branched, the young parts and the twigs are covered with bifid, appressed, whitish hairs.

Leaves: Arranged spirally, imparipinnate; stipules narrowly triangular, 1.5–3 mm long; petiole up to 2 cm long, rachis up to 7 cm long; covered with appressed hairs and sagging with a groove on the upper side. stipels narrowly triangular, leaflets elliptical to obovate, usually glabrous above, thinly hairy below. The apex is rounded and mucronate, the base is wedged or rounded. The margin is entire.

Inflorescence: Sessile, many-flowered axillary raceme up to 6 cm long but usually much shorter; bracts narrowly triangular, more or less persistent.

Flowers: The flowers are small, about 5 mm long, bisexual, papilionaceous type, with pedicel 1 to 1.5 mm long.

Calyx: Calyx tube with five triangular lobes, white appressed hairy;



Corolla: Corolla of about 4 mm long: standard oval, whitish pink with reddish veins, two wings with very short claw, pink, and a keel with 'lateral spurs, pink to red.

Androecium: Stamens 10, 4–5 mm long, upper one free, the other 9 united into a tube around the ovary.

Gynoecium: Superior Ovary pubescent, with single carpel, surmounted by a long style.

Fruit: A linear pod 20–35 mm long, straight or slightly curved, rounded in cross-section, brown when ripe, 7–12-seeded with slight constrictions between the seeds.

Seeds: The seeds are shortly oblong, about 2 mm long and 1.5 mm wide, rhombic in cross section.

Pollination: Cross pollination by insects.

Center of Origin: Southern Asia, probably India.

Related Species

1. *Indigofera spicata*
2. *Indigofera flabellata*
3. *Indigofera decora*
4. *Indigofera hilaris*
5. *Indigofera rothii*
6. *Indigofera astragaline*
7. *Indigofera australis*
8. *Indigofera hirsuta*
9. *Indigofera pendala*

CULTIVATED TYPES OF INDIGO TREE

1. *Indigofera tinctoria* - Original Indigo tree: Asian or Indian origin found below 1000 m altitude. Thin stem with sparsely and shortly persistent hairs; leaflets 4 to 6 pairs. Calyx hairs white. Standard corolla greenish. Pods linear, narrow containing 8 to 12 seeds. Cultivated for dye and green manure purpose. It has two varieties viz., Indigofera tinctoria var. arcuata and Indigofera tinctoria var. tinctoria.

2. *Indigofera suffruticosa* - American Indigo tree: American origin found below 1000 m altitude. Stem is slightly angular with dense and persistent hairs. Calyx hair brown in colour, standard red or pink, pods larger, curved and oblong, containing 3 to 6 cuboid seeds.

3. *Indigofera arrecta*- High altitude Indigo tree: Found in high altitude between 1000 to 2000 m. Used mainly for dye purpose. Leaflets larger and fewer than tinctoria. Calyx hairs brown in colour. Standard red or pink in colour. Pods are medium in size and contains 4-6 seeds.

USES OF INDIGO TREE

1. Indigo tree is cultivated as a green manure crop in Coffee plantations, and preceding rice, maize, cotton and sugarcane crops.
2. Indigo dye is obtained from the leaves by soaking the leaves in water to ferment by which Glycoside indican is converted to Indigotin.
3. The residue remaining after dye extraction is used as a manure.
4. Indigo tree fixes atmospheric nitrogen as a good Nitrogen catch crop, thereby reducing the nitrate leaching in the groundwater.
5. Indigo leaves are used as fodder for camels, sheep and Goats in Kenya.
6. In Cameroon, the twigs are used as toothbrush.
7. The leaf extract is used to treat epilepsy, nervous disorders, asthma, fever, stomach complaints as well as to treat skin diseases.
8. The leaf extract is also used to treat burns and sores on cattle and horses.
9. The tincture of seed is used to kill lice.
10. Root infusion is used as an antidote for snake bite, dog bite, scorpion sting and for insect bite.
11. Its leaf extract is used in preparing hair oil and hair colour oil.
12. The dried, crushed leaves are used as an ingredient in commercial cosmetic preparations as a masking agent and tonic.

GREEN LEAF MANURE VALUE OF INDIGO TREE

Indigofera tinctoria is useful as green manure, used in India in coffee plantations and preceding rice, maize, cotton and sugarcane. In traditional rainfed rice cropping systems in the Philippines It is a popular green manure, increasing rice yield while reducing the need to supply expensive nitrogen fertilizer to about half. The residue remaining after indigo extraction is also applied as manure. Another reason to grow *Indigofera tinctoria* as green manure is because it is a good N catch crop, reducing the amount of fertilizer NO3 leaching to the groundwater. The leaves of Indigofera tinctoria contain per 100 g dry matter approximately: N 5.1 g, P 0.35 g, K 1.4 g, Ca 3.9 g. The ash (4.4 g) contains up to 9.5% soluble potassium salts.

The indigo refuse after dye extraction contains approximately: N 1.8 g, P 0.2 g, K 0.25 g. **I**ndigo plants yield about 8 to 10 t/ha that is equivalent to 180 to 200 kg N/ha. By nitrogen fixation it can accumulate 45 kg N/ha in 45 days after planting.

ADVANTAGES OF INDIGO TREE

1. It is a fast-growing tree yielding sufficient green leaves, once it is well established.
2. It is drought tolerant and can tolerate dry condition up to a period of six months or even more.
3. Under irrigated condition it gives better green leaf yield.
4. It can be grown as a companion crop with exerting competitive effect on the yield of the companion crop.
5. It act as a soil cover especially during dry season.
6. It produces numerous seeds (15 seeds per pod) and easily propagated through seeds.
7. It can grow well in clayey soil.
8. It can be grown as a hedgerow and as an Agroforestry species and in disturbed lands and grasslands.

LIMITATIONS OF INDIGO TREE

1. It has a slow growth phase for the first 45 months to well establish.
2. It cannot tolerate excess water logging and excess heat.
3. It is susceptible to blight, green catterpillar, grasshopper and locust

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

Article ID: AG-V04-I12-58

PORTIA TREE-AN EVERGREEN GREEN MANURE TREE

[1]Preetha, K., [2*]V. Krishnan, V., [1]R. Praveen, [1]S. Lakshmipriya, [1]J. Arathi, and [21]S. Aparna

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

Portia tree, botanically called *Thespesia populnea* (2n: 24), belonging to family: Malvaceae, is a pantropic tree found along sea coasts, often in locations where sandy beaches covered by *Casuarina equestifolia*. give way to coral outcrops and in Barringtonia vegetation. The species can also be found on rocky coasts such as in Malaysia. This tree is native to India, Australia and China.

BOTANICAL DESCRIPTION OF PORTIA TREE

Habitat: Portia tree is a plant of the moist to wet, lowland tropics and warm subtropics, where it is found at elevations up to 150 metres. Portia tree is a suitable tree for dry locations and is highly tolerant of saline conditions, sandy soils and soils with poor nutrients. It grows up well with an annual rainfall of 1000 to 5000 mm and can withstand temperatures as low as 4O C.

Habit: *Thespesia populnea* is a shrub or medium-sized evergreen tree, up to 20 m tall with a dense crown. Bark greyish. Twigs densely covered with brown to silvery scales and glabrescent.

Root: Deep and well-developed tap root.

Stem: The trunk can be 2 feet in diameter at full maturity. The bark is corrugated, with scaly twigs. The branches are widely spread and usually horizontal, making for an ideal shade tree.

Leaves: Alternate, simple; petiole 5-8 (max. 16) cm long; stipule lanceolate to subulate, 3-10 mm long, scaly; blade orbicular, deltoid, ovate or oblong, 7-23 x 5-16 cm, apex acuminate, base generally cordate, sinus deep and narrow, rather fleshy and shiny, palmately 7-veined, in the axils of the basal veins beneath, mostly with saccate nectarines, main veins yellow.

Inflorescence: A large solitary axillary flower; pedicel 2.5-8 cm long, erect or ascending, sometimes articulate with 2 scale like bracts near the base.

Flower: Flowers bisexual, yellow, showy and bell shaped: pedicels 20-50 mm long, jointed near the base, glabrescent; involucre of bracts 3-5 or 0, 5-15 x 2-3 mm, oblong-lanceolate, acute, sub-coriaceous, densely scaly, cauducous; pale yellow flowers with maroon or purple centers turn purplish-pink as they fertilize with in their short one day life.

Calyx: Campanulate, subtruncate, 12-14 mm long, 18 mm in diameter, densely adpressed hirsute within, scaly, glabrescent outside.

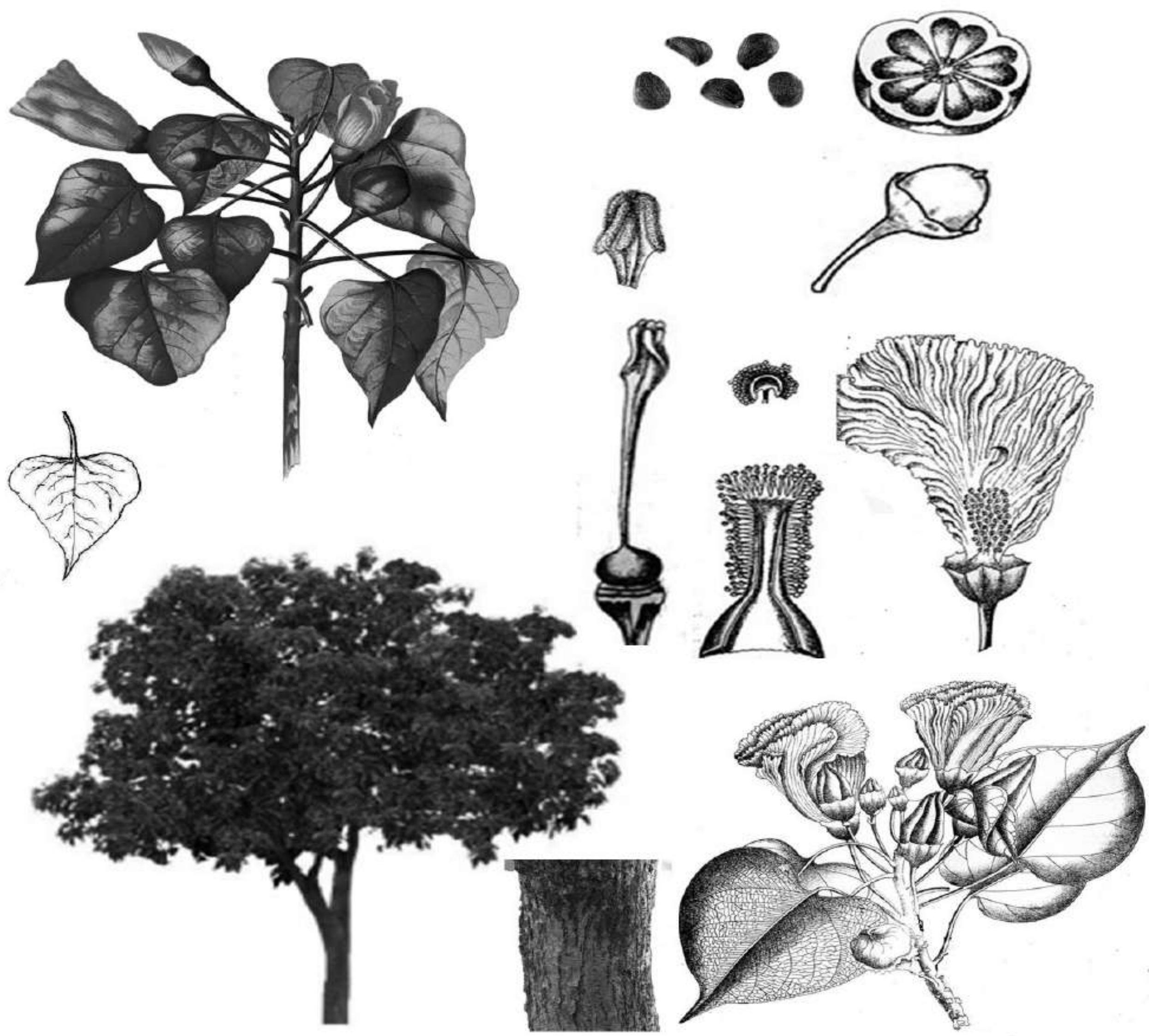


Fig. 1. ***Thespesia populnea*** **-Portia Tree: Botanical illustration**

Corolla: Broadly campanulate, up to 6 cm long and wide, pale yellow with dark purple centre; petals 5, obliquely obovate, 6-7 x 4.5-6 cm.

Androecium: Monadelphous; staminal column toothed at the apex; numerous anthers.

Gynoecium: Ovary half inferior, five celled; style club-shaped at the apex, 5-furrowed.

Fruit: A globose capsule, 2-4.5 cm in diameter, faintly 5-angular, 55-celled, apex obtuse or slightly depressed, with disc like persistent calyx at the base of the young fruit, usually indehiscent, exuding a bright yellow gum when cut.

Seeds Four per cell, obovoid, 8-15 x 6-9 mm, slightly angular, covered by closely matted silky hairs.

Pollination: Cross pollination by bees.

Center of Origin: Tropical Asia

RELATED SPECIES

Thespesia cubensis

Thespesia garckeana

Thespesia grandiflora

Thespesia mossambicensis

Thespesia acutiloba

Thespesia danis

USES OF PORTIA TREE

1. Young flower buds and leaves are eaten raw or fried in butter.
2. The leaves are a good source of protein, calcium and phosphorus for livestock.
3. Bark yields a strong fibre used for cordage, fishing lines, coffee bags and for caulking boats.
4. The fine-grained, strong, hard and durable wood is used for light construction, flooring moulds, musical instruments, utensils and vehicle bodies.
5. As it is very durable under water, it is popular for boat building.
6. Wood is used for horse-drawn carts and wheel barrows, to carve canoe paddles, bowls, plates and utensils. It is resistant to insect attack.
7. The wood and the yellow gum from the fruit and flowers yield a dye, and the bark produces tannin.

8. The heart wood has a healing property useful in treating pleurisy and cholera, colic and high fevers; it is carminative.

9. The cooked fruit crushed in coconut oil provides a salve, which, if applied to the hair, will kill lice.

10. The sap of the leaves and decoctions of most parts of the plant are used externally to treat various skin diseases.

11. A decoction of the astringent bark is used to treat dysentery and haemorrhoids, and a maceration of it is drunk for colds.

12. The fruit contains an antibiotic and the juice is used to treat herpes. Other extracts of the plant have significant antimalarial activity.

13. Leaf and bark decoctions are taken for high blood pressure. Leaf tea is taken for rheumatism and urinary retention.

14. Because of its tolerance of saline conditions, Portia tree is suitable for coastal erosion control.

15. Leaves are used for green manure. Wood chippings have also been tried as a green manure.

16. Portia tree is a sacred tree, often planted near temples. Elsewhere, it has been planted as an ornamental and roadside tree.

17. In mangrove areas, Portia tree is often planted to consolidate ridges and bunds in an aqua-silvicultural system for prawn production.

18. It can be used as live support for vanilla plants.

19. It can be grown as live fence in farmyard, cattle yard and houseyards.

20. Its timber is of great value for making artistic carvings and sculptures.

GREEN MANURE VALUE OF PORTIA TREE

Portia tree can be grown on ridges and bunds of field of all soil types. It grows rapidly in height for first few years and then slows down at seven to ten years of age. It can live up to 25-40 years depending on soil condition. It can tolerate heavy pruning, but regrowth is slow. The young leaves and toppings can be used as green leaf manure crop, especially for rice cultivation.

ADVANTAGES OF PORTIA TREE

1. Highly tolerant to saline soils with pH up to 8 and can tolerate occasional tidal inundations for a short period.

2. Very drought resistant and can tolerate a dry spell up to eight months.

3. Tolerant to occasional, short lived inundation by sea tides.

4. The trees are very wind tolerant and can withstand even salt laden winds.

5. Seeds are produced in a water-proof capsules that can float in salt water for a considerable period without losing its viability, which makes it suitable for spreading along the coastal areas.

6. It can tolerate occasional tidal inundations and in sandy soils.

7. It can be grown as live fence in farmyards, cattle shed and houseyards.

8. The trees can be grown to provide live support to vanilla plants.

9. It can thrive well in sandy coastal soils, volcanic limestone and in rocky soils.

10. It can tolerate heavy pruning and can regrow, but in a slow phase.

LIMITATIONS OF PORTIA TREE

1. Its growth after initial establishment is slow and would take 25 to 40 years to produce economic timber.

2. Portia tree act as host for several cotton pest such as cotton stainers, spiny boll worm and boll weevils.

3. It is susceptible to root rot and stem rot caused by the fungus *Phellinus noxius*.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

NEEDFUL NEEM TREE

Article ID: AG-VO4-I12-59

[1]Aparna, F. S., [2*]V. Krishnan, V., [1]K. Preetha, [1]R. Praveen, [1]J. Arathi and [1]S. Lashmipriya,

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

Neem tree is botanically called *Azadiracta indica* (2n: 28, belonging to family: Meliaceae, a multipurpose tree that is highly popular in India, where it provides food and insecticide, and is used for its great number of ethnomedicinal properties. Neem is native of dry areas of the Indian subcontinent, Myanmar and China. It was naturally distributed in Thailand, Malaysia and Indonesia and has become one of the most wide spread trees in tropical and subtropical areas including African and Australian continents. Neem trees may live for more than two centuries.

Botanical Description of Neem Tree

Habitat: Neem naturally occurs in dry deciduous and thorn forests, or acacia forests. Neem can be found from sea level up to an altitude of 1500 m in places where average annual rainfall ranges from 400 to 1200 mm and where average annual maximum temperatures may be as high as 40°C. It is an evergreen that shed its leaves during dry season.

Habit: Neem is a medium-sized tree, reaching 15 to 30 m in height, with a large rounded crown up to 10-20 m in diameter.

Root: Neem has a deep tap root and is a mycorrhizal-dependent species. The roots penetrate the soil deeply, at least where the site permits and particularly when injured, they produce suckers. This suckering tends to be especially prolific in dry localities.

Stem: The short, usually straight trunk has a moderately thick with strongly furrowed bark. The bark is grey, becomes fissured and flakes in old trees.

Leaves: The leaves are alternate, petiolated, clustered at the end of the branches, unequally pinnate, glabrous and dark glossy green at maturity, 20-40 cm in length and bearing 10-20 leaflets. The leaflets are 5-10 cm long x 1.2-4 cm broad, sickle-shaped and slightly denticulate.

Inflorescence: Drooping axillary cluster up to 30 cm long, with numerous bisexual flowers.

Flowers: The flowers fragrant, small, white, bisexual. Bracteate, actinomorphic, hermaphrodite, complete, hypogynous, scented, disciferous.

Calyx: Made up of 5 sepals, gamosepalous, light green, valvate.

Corolla: Made up of 5 petals, polypetalous, imbricate. An annular disc present between petals and stamens.

Androecium: Made up of 10, or 8 - 12 monadelphous, filaments unite to form a staminal tube seated at the base of annular disc, anthers dithecous, introrse.

Gynoecium: Tricarpellary, syncarpous, superior, trilocular, two ovules in each locule, axile placentation, style simple, stigma trifid. They have a honey like scent and attract many bees.

Fruits: The fruit is a smooth, ellipsoidal drupe, up to almost 2 cm long. When ripe, it is yellow or greenish yellow and comprises a sweet pulp enclosing a seed. They have a thin epicarp, a mucilagenous fleshy mesocarp and a hard endocarp.

Seed: The seed is composed of a shell and a brown coloured kernel, each about half of the seed's weight.

Pollination: Cross pollinated by bees.

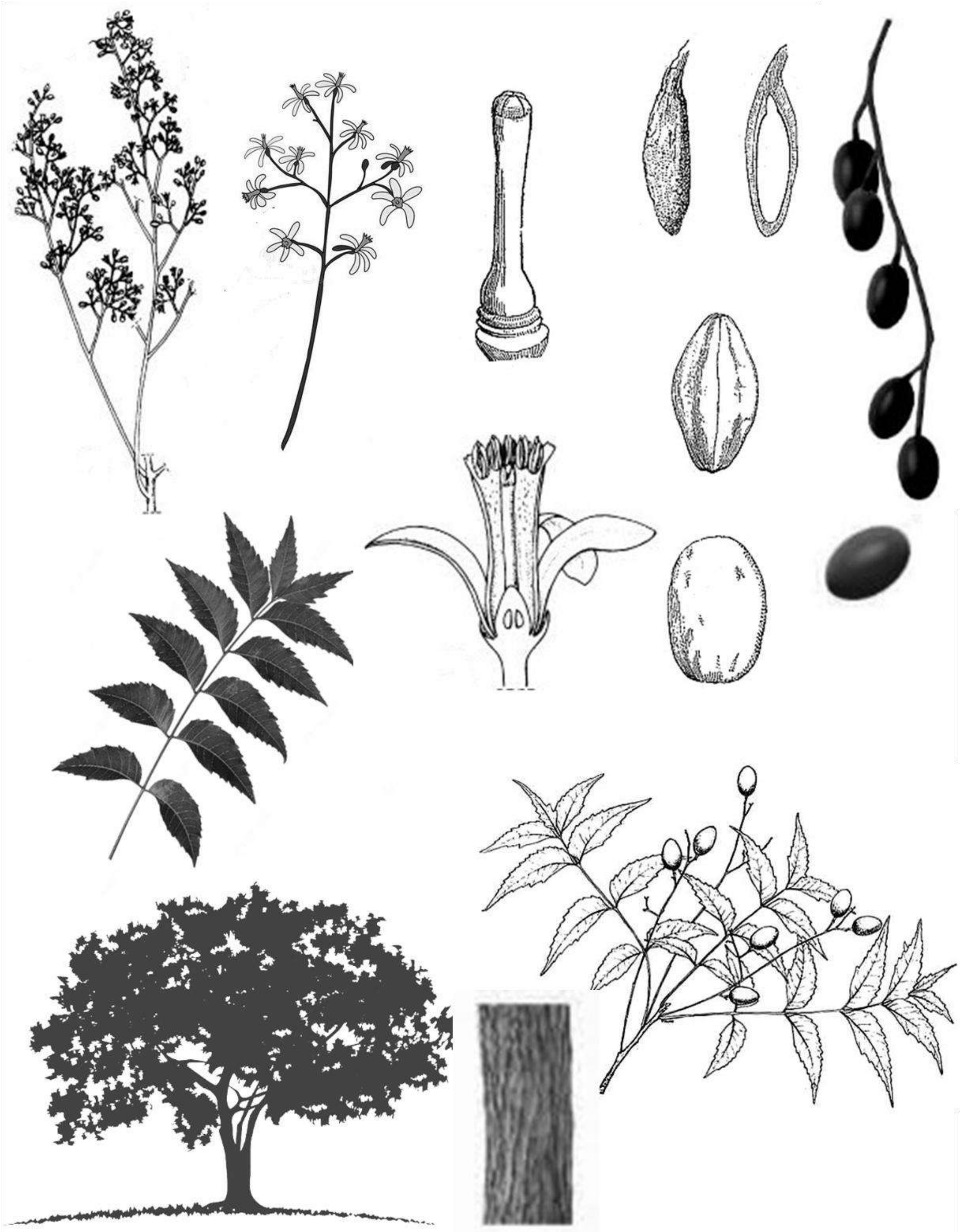
CENTER OF ORIGIN: Indo-Burma, where it is common throughout the Central dry zone and the Siwalik hills.

RELATED SPECIES

Melia azadarach; This is African neem tree. This species genera have similarities with *Azaidracta indica*. *Melia* has two to three pinnate leaves with one pair of glands as against unipinnate leaves with single gland of *Azadiracta* and ovary of *Melia* is four to eight locular as against trilocular of A*zadiracta*.

USES OF NEEM TREE

1. It is planted as a shade tree on avenues and common places in villages.
2. Neem trees act as good wind breaks, but can not withstand cyclonic winds and typhoons.
3. Neem is a suggested tree for afforestation. 4. Neem tree are suitable for sand dunes fixation and for soil reclamation in areas where salinity occur.



5. Neem leaves and toppings are used as green leaf manure. Annually about 350 kg of leaves per year.
6. Neem seed oil extract has industrial and ethnomedicinal use in India.
7. Neem extract can protect plants from foliage eating insects without affecting pollinating insects such as bees.
8. Neem limonoids *viz*., Melantriol and Salanin act as anti feedants against insects.
9. The active ingredient Nimbindin and Nimbin have antiviral properties.
10. Neem seed contain Azadirachtin a limonoid that act as a repellent for insects, inhibiting them from feeding.
11. Neem tree provide termite proof timber for furniture and construction works.
12. Neem poles and twigs provide valuable fire wood and used to make good charcoal.
13. Neem honey is popular and reported to contain no Azadirachtin.
14. Neem twigs are used as tooth brush.
15. Neem leaves, bark and seed extracts are used as ethnomedicine and ethnoveterinary medicine.
16. The young flowers are dried and used to prepare neem flower curry that has medicinal value.
17. Neem seed cake are used as an organic manure that improves the efficiency of added fertilizer, as it delays the nitrification of soil.
18. Neem is intercropped with pearl millet and Sugarcane crop.

ADVANTAGES OF NEEM TREE

1. It is highly drought tolerant and can tolerate dry spell of two to three months in a year.
2. Neem extracts have insect antifeedant and antiviral activity.
3. It can grow in soils of acidic as well as saline pH ranging from 3 to 9.
4. It does well in shallow, stony, sandy poor and marginal sloping places and rocky crevices.
5. It grows well in full sunlight, but can withstand shade during first year.
6. Neem tree can extract nutrients from highly leached sandy soils.
7. Neem tree can withstand an annual rainfall of 2500 mm, if the soil is well drained.
8. Neem trees can be pollard up to one third height and regrows very fast.

9. Neem trees can be coppiced even up to near ground level and reestablishes exceptionally at a faster rate.
10. Its root system is large enough to feed the full grown tree when it sheds all its leaves during dry season.
11. It can live even up to 200 years.

LIMITATIONS OF NEEM TREE

1. Though not attacked by many insect pest, it is affected by scale insect *Aonidiella orientalis*.
2. Though renowned for termite resistance, young week trees are attachked bytermites occassionally.
3. Fire kills neem tree outright.
4. Hurricanes, cyclones and typhoons uproot even large neem trees.

CHEMICAL COMPOSITION

Neem leaves: Contains crude protein 16.6%, crude fiber 16.8%, minerals 12%., tannins 11% and Saponins 2.5%.

Neem seed: Contains 37% crude protein, 15% crude fiber and minerals less than 1%.

Neem seed cake: Contains Crude protein 16.7%, crude fiber 24.3% and minerals 12.4%. Rich in Zinc, Iron. Nitrogen 3.5%, Phosphorous 0.4% and Potassium 2.0%.

Toxicity: Neam limonoids such as Azadirachtin, Melantriol, Salanin, Nimbin and Nimbindin etc., have toxic effect on human and animal species including cattle and poultry. In sheep if may cause fatal damage and in poultry at 2.5% of diet may cause many histopathological impact.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

NEMATODES IN HORTICULTURE: CHALLENGES AND SOLUTIONS FOR HIGH-VALUE CROPS

Article ID: AG-VO4-I12-60

Prabhu, S[1] and R.Poorniammal[2*]

[1]Dept of Plant Protection, Horticultural College and Research Institute, TNAU,

[2]Dept of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore, India Periyakulam, Tamil Nadu, India

*Corresponding Author Email ID: r.poornii@tnau.ac.in

Abstract

Nematodes are a significant challenge in horticulture, particularly for high-value crops such as fruits, vegetables, ornamentals, and nuts. These microscopic roundworms cause substantial damage to plant roots, stems, and leaves, leading to reduced yields, poor quality, and significant economic losses. Key nematode pests, including root-knot nematodes (*Meloidogyne* spp.), cyst nematodes (*Heterodera* spp.), and lesion nematodes (*Pratylenchus* spp.), are major threats worldwide. The hidden nature of nematodes and the subtlety of their symptoms make early detection and management difficult, further exacerbating their impact. Traditional control measures, such as chemical nematicides, pose environmental and health risks, necessitating sustainable alternatives. Integrated management strategies, including crop rotation, biological control agents, resistant crop varieties, and soil health management, have shown promise in mitigating nematode damage. Advances in precision agriculture, molecular diagnostics, and biotechnological innovations such as RNA interference (RNAi) are opening new avenues for targeted and effective nematode control. This paper explores the challenges posed by nematodes in horticulture and highlights sustainable solutions that can enhance productivity and profitability while minimizing environmental impact. Adopting these strategies is essential for ensuring the long-term viability of high-value horticultural crops in the face of these persistent pests.

Keywords: Biocontrol agents: High value crops; Plant parasitic nematodes

Introduction

Horticulture has become a significant and promising avenue for agricultural diversification, transforming traditional subsistence farming into a high-value commercial enterprise. This shift has brought about remarkable improvements in the socio-economic conditions of farmers across various regions. With its rich diversity of agro-climatic conditions, India is often referred to as a horticultural paradise. The country produces approximately 234.2 million tonnes of horticultural produce annually from around 20.66 million hectares of land. This sector has demonstrated its potential to boost agricultural productivity, enhance household nutritional security, and contribute to income generation through diversification, value addition, employment opportunities, and exports. Horticulture stands as a pivotal component of sustainable agriculture and economic development.

Nematodes pose a significant threat to fruit orchards and plantation crops across the country. This challenge has intensified with the emergence of new nematode species, such as *Meloidogyne enterolobii*, which has become a growing concern for guava cultivation. Farmers growing fruits like guava, pomegranate, citrus, and banana are increasingly dealing with nematode issues, including root-knot nematodes, citrus nematodes, reniform nematodes, burrowing nematodes, and lesion nematodes.

A major concern is the hidden nature of nematodes and their non-specific, subtle symptoms, which often leave farmers unaware of their presence. This lack of awareness facilitates the unchecked multiplication of nematodes in orchards. Recently, guava and pomegranate growers have reported problems such as leaf yellowing, stunted growth, and reduced productivity in trees. Soil and root analyses of these affected trees frequently reveal severe infestations of root-knot nematodes (Yadav and Patil, 2021)

Globally, crop losses caused by plant-parasitic nematodes in fruit crops are alarmingly high, with average annual yield reductions estimated at 20–40%. These losses are exacerbated when multiple nematode species infest the same area or when nematodes interact with secondary pathogens, such as fungi and bacteria, forming complex disease syndromes. The compounding effects of such infestations highlight the urgent need for awareness and effective management strategies.

Nematodes are a diverse group of microscopic organisms, with over 25,000 species identified and estimates suggesting millions more exist. They can be free-living, parasitic, or predatory, with plant-parasitic nematodes (PPNs) being the most concerning for horticulture. These nematodes attack plant roots, stems, leaves, and even flowers, causing a range of symptoms such as stunted growth, wilting, reduced yields, and poor fruit quality.

Among the most notorious nematodes are the root-knot nematodes (*Meloidogyne* spp.), cyst nematodes (*Heterodera* and *Globodera* spp.), lesion nematodes (*Pratylenchus* spp.), and burrowing nematodes (*Radopholus similis*). These pests compromise plant health by feeding on root cells and disrupting water and nutrient uptake, often creating entry points for secondary pathogens like fungi and bacteria (Siddiqui and Futai, 2009)

Challenges Posed by Nematodes

Nematodes present unique challenges in horticulture:

1. **Difficult Detection**: Due to their microscopic size and subterranean activity, nematodes often go unnoticed until significant damage is apparent. Diagnosis typically requires laboratory analysis of soil and plant tissues.
2. **Wide Host Range**: Many nematodes have broad host ranges, making crop rotation less effective in some cases. For instance, root-knot nematodes can infect over 2,000 plant species.
3. **Economic Losses**: Nematodes are responsible for billions of dollars in crop losses annually. In high-value horticultural crops, even small yield reductions can lead to significant financial setbacks.
4. **Climate Change**: Rising temperatures and changing precipitation patterns are expanding the geographic range of certain nematodes, potentially increasing their impact in regions previously unaffected.
5. **Environmental Impact of Control Measures**: Traditional chemical nematicides are often toxic, expensive, and harmful to beneficial soil organisms, necessitating more sustainable approaches.

Integrated Management Strategies

Effective nematode management requires a multi-pronged approach that combines cultural, biological, and chemical strategies, along with advancements in genetic resistance.

1. Cultural Practices

- **Crop Rotation**: Alternating susceptible crops with non-host crops can help reduce nematode populations. However, its effectiveness depends on the specific nematode species and their host preferences.

- **Soil Solarization**: Covering soil with transparent plastic during hot months can heat the soil to lethal temperatures, suppressing nematodes and other pathogens.
- **Cover Crops**: Planting cover crops like marigolds (*Tagetes spp.*) can reduce nematode populations. Marigolds release compounds toxic to nematodes.

2. Biological Controls

- **Beneficial Nematodes**: The use of entomopathogenic nematodes (EPNs) and the presence or absence of an insect host strongly suggest that the symbiotic bacteria associated with EPNs may play a significant role in the observed adverse effects on plant-parasitic nematodes (PPNs). These effects likely result from the production of deterrent factors by the symbiotic bacteria, combined with factors designed to weaken or kill the insect host. While the fundamental concepts of these interactions are relatively straightforward, the intricate details influencing the system make it remarkably complex.
- **Bacteria**: Several bacterial species exhibit control or suppression activity against various plant-parasitic nematodes (PPNs). For instance, *Pasteuria penetrans* directly parasitizes nematodes, while other genera, such as plant-growth-promoting bacteria like *Bacillus*, *Agrobacterium*, *Azotobacter*, and *Pseudomonas*, produce toxins capable of killing nematodes. Among the *Bacillus* species, *B. cereus*, *B. firmus*, *B. thuringiensis*, *B. licheniformis*, and *B. nematocida* have demonstrated high efficiency in controlling PPNs.
- **Fungi**: Numerous fungal genera have been reported to exhibit inhibitory effects on *Meloidogyne* species. These include *Acremonium*, *Alternaria*, *Arthrobotrys*, *Chaetomium*, *Cladosporium*, *Clonostachys*, *Diaporthe*, *Drechslerella*, *Epichloë*, *Epiccocum*, *Fusarium*, *Gibellulopsis*, *Melanconium*, *Metacordyceps*, *Monacrosporium*, *Neotyphodium*, *Paecilomyces*, *Phialemonium*, *Phyllosticta*, *Piriformospora*, *Purpureocillium*, *Talaromyces*, and *Trichoderma* **(**Furmanczyk et al., 2023)

3. Chemical Control

While chemical nematicides are effective, their environmental and health concerns have led to stricter regulations. Newer formulations are designed to be more targeted and environmentally friendly. Nematicidal seed treatments and soil drenches offer promising options.

4. Resistant Varieties

Breeding nematode-resistant crop varieties is one of the most sustainable management strategies.

Advances in biotechnology and gene editing have enabled the development of crops with enhanced resistance to specific nematode species.

5. Soil Health Management

Building healthy soils with organic amendments such as compost and biochar can suppress nematode populations and support beneficial microbes. Practices like reduced tillage and maintaining soil cover can also enhance resilience against nematodes.

Innovative Approaches and Future Prospects

Emerging technologies are revolutionizing nematode management. Precision agriculture tools, such as remote sensing and drones, help monitor nematode damage at early stages. Molecular diagnostics provide faster and more accurate identification of nematode species. Additionally, RNA interference (RNAi) technology is showing promise in silencing nematode genes essential for their survival. Research into the microbiome of nematode-infested soils is uncovering new biocontrol opportunities, while nanotechnology is being explored for delivering targeted treatments with minimal environmental impact.

Conclusion

Nematodes are a persistent and costly challenge in horticulture, particularly for high-value crops. By integrating traditional methods with innovative technologies, growers can mitigate their impact effectively and sustainably. Continued research, farmer education, and policy support are essential to ensuring that horticulture remains a viable and profitable sector in the face of these microscopic adversaries. By embracing an integrated approach, the horticultural community can outsmart nematodes and ensure the continued supply of nutritious and aesthetically pleasing crops to meet global demands.

References

Yadav, S., and A. Patil, J. (2022). The Emerging Nematode Problems in Horticultural Crops and Their Management. IntechOpen. doi: 10.5772/intechopen.99292

Furmanczyk EM, Malusà E. (2023). Control of Nematodes in Organic Horticulture Exploiting the Multifunctional Capacity of Microorganisms. Horticulturae. 9(8):920. https://doi.org/10.3390/horticulturae9080920

Siddiqui, Z.A and Futai, K. (2009). Biocontrol of Meloidogyne incognita on tomato using antagonistic fungi, plant-growth-promoting rhizobacteria and cattle manure. Pest Management. Science. 65, 943–948.

Volume: 04 Issue No: 12

PESTS OF CORIANDER AND THEIR MANAGEMENT

Article ID: AG-VO4-I12-61

Dr. M. Devi*

Associate professor (Agricultural Entomology), MIT College of Agriculture and Technology, Musiri, Trichy, Tamil Nadu, India

*Corresponding Author Email ID: deviagri84@gmail.com

Introduction

Coriander crops attracted large number of insect pests and pollinators during its crop growth in the field. It also attracts numbers of storage pests during storage of seeds. The appearance of pests started at early vegetative stages and lasted till the seed mature. Since this crop attract large number of natural enemies of the pests and pollinators, it is important to apply judicious use of insecticides to control the pests and prevent the loss of beneficial insects like predators/parasitoides/pollinators which is vital components of IPM. Though coriander occupies the first position in area and production among all the seed spices, yet the productivity is very low. The major reasons for low productivity of coriander are the biotic and abiotic stresses.

The widespread introduction of high yielding cultivars and adoption of intensive crop management practices resulted in substantial increase in yields. Side by side it has also improved the conditions for insects, diseases, weeds, rodents and nematodes. All living organism, which causes loss to the crop in terms of yield and quality are called pests. Yield losses due to these pests ranges from 30-40%. Coriander is an annual herb plant used as a spice in kitchen. It is mostly grown for its fruit and green leaves to provide flavor in dishes. Dry seeds of coriander contain essential oils which are used in confectionary, to mask offensive odours in pharmaceutical industry and for flavoring liquors. Green leaves are good source of Vitamin C and are used for making chutney, soups and sauces etc. Coriander also has good medicinal value. Tamil Nadu, Karnataka, Madhya Pradesh and Rajasthan are major producers of Coriander in India.

Cotton Whitefly : *Bemisia tabaci* (Aleyrodidae; Hemiptera)

Damage symptoms:

- The nymphs and adult suck sap of the plant
- Chlortic spots on the leaves latter coalesce forming irregular yellowing of leaf tissues
- Severe infestation results in premature defoliation
- Development of black sooty mould due to the excretion of honey dew

Identification:

Nymph: Greenish yellow, oval in outline

Adult : Minute insects with yellow body covered with a white waxy bloom.

Management:

- Release predators such as mirid bugs , dragon fly, spider, lace wings etc
- Field sanitation and rouging
- Install yellow sticky traps @ 2/acre
- Spray NSKE 5%
- Spray any of following insecticides
  - Acephate 2g lit or Quinalphos 25EC@ 2l/ha and Triazophos 40EC @ 2l/ha

Aphid : *Hyadaphis coriandri* (Aphididae; Hemiptera)

Damage symptoms:

- Infesting tender shoots and under surface of the leaves
- Both nymphs and adults congregate colonise on ventral and suck cell sap
- Curling and crinkling of leaves and stunted growth
- Development of black sooty mould due to excretion of honeydew

Identification:

- Eggs: Eggs are very tiny, shiny-black
- Nymphs: yellowish or greenish brown found on undersurface of leaves
- Adults: Adults are small, soft-bodied insects with two long antennae that resemble horns.

Management:

- Remove and destroy affected plants parts
- Release of predators like Coccinelid beetles, green lace wing
- Install yellow sticky trap 2/acre
- Spray any one of following insecticides

- Imidacloprid 200SL at 100ml/ha
- Methyl Demeton 25EC 500ml/ha
- Dimethoate 30EC 500ml/ha
- Thiamethoxam@4gm/10Ltr of water.

Indigo caterpillar: *Spodoptera exigua* (Noctuidae; Lepidoptera)

Damage symptoms:

- In early stages, the caterpillars are gregarious and defoliate content of leaf lamina giving it a papery white appearance.
- Irregular holes are produced on leaves initially and later skeletonisation occurs, leaving only veins and petioles.

Identification:

- Eggs: Female lays about 300 eggs in clusters. The eggs are covered over by brown hairs
- Larva: It is velvety, black with yellowish – green dorsal stripes and lateral white bands
- Pupa: pupation takes place inside the soil.
- Adult: Forewings pale grey to dark brown in color having wavy white crisscross markings. Hind wings are whitish with brown patches.

Management:

- The pest may be suppressed by removal and destruction of infested plants
- Castor as trap crop and Light trap @ 1/ha, Sex trap with spodolure @12/ha
- Spray 2.5kg of carbaryl 50 WP in 625l of water per ha
- Release of natural enemies like Braconid wasp, Dragon fly, Reduviid preying mantid etc
- Spray SL NPV @1.5x10 12POBs/ha +2.5kg crude sugar + 0.1% teepol

Mite: *Tetranychus telaris* (Tetranychidae; Acarina)

Damage symptoms

- The mites frequently attack the coriander crop and whole plant becomes whitish yellow and appears sickly.
- It mostly feeds on young leaves and the infestation is more severe on young inflorescence.
- Mites are seen on the lower side of the leaves and when serious, cause webbing and feed from within the web and Plants get stunted at severe infestation.

Identification:

Egg: Eggs are microscopic, laid in masses and Nymphs is yellowish in color

Adult: The mites are very small measuring about 0.5 mm in length, metallic brown to black with pale yellow legs. Their forelegs are distinctively longer than the other three pairs

Management:

Encourage the activity of predatory mite, *Amblyselus ovalis, Amblyselus persimilis*

Apply phorate 10%G @10kg/ha

Spray any of following insecticides

- Profenophos 2ml/lit, Abamectin 2ml/lit and Oomite 2ml/lit

Cutworm: *Agrotis sp (*Noctuidae; Lepidoptera)

Damage symptoms:

- The larva cuts the plants from ground level and makes them to fall down.
- Infestation of this pest starts at the initial stage of plants resulting in heavy loss to the crop.

Identification:

Egg: white in color initially & later turns brown

Larva: young caterpillar are light green with black head

Adult : Forewing is uniformly dark brown. Hind wings are whitish to grey.

Management

- Collect and destroy egg masses & larva
- Spray any of following insecticides
  - Emamectin benzoate 5% SG4g/10lit
  - Flubendiamide 20WDG 6g/10lit
  - Indoxacarb 14%SC 6.5ml/10lit

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

PRE BREEDING (GENETIC ENHANCEMENT) – ITS APPLICATION IN CROP IMPROVEMENT

Article ID: AG-V04-I12-62

***N.Premalatha[1] and D.Kavithamani[2]**

[1.] Associate Professor (PBG), Department of Cotton, TNAU, Coimbatore, Tamil Nadu, India

[2.] Assistant Professor (PBG), Department of Millets, TNAU, Coimbatore, Tamil Nadu, India

*Corresponding Author Email ID: npremalatha@gmail.com

Introduction

The term genetic enhancement was first used by Jones in 1983. It refers to transfer of useful genes from exotic or wild types into agronomically accepted background. In 1984, Rick used the term pre- breeding to describe the same activity. Now terms genetic enhancement and pre- breeding are used as synomyms and interchangeable. Genetic improvement in some specific traits of certain crops may become s priority objective for various agronomic, economic etc., reasons. Pre-Breeding deal to enhance genetic variability in the germplasm and the improved germplasm can be readily used in regular breeding programme for cultivar development The genetic diversity of crop plants is the foundation for the sustainable development of new varieties for present and future challenges which arises due to the various biotic and abiotic stresses. The genetic diversity provides a way to plant breeders to develop new and more productive crops / varieties through selection, hybridization and breeding, that are resistant to virulent pests and diseases and adapted to changing environmental conditions. Diversity of genetic material contained in traditional varieties, modern cultivars, crop wild relatives and other wild species.

What is Pre – breeding ?

Pre-breeding aims to isolate desired genetic traits from unadapted material like crop wild relatives, that cannot be used directly in breeding populations and introduce them into breeding lines that are more readily crossable with modern, elite varieties. Pre-breeding involves all the activities associated with identification of desirable traits and/or genes from unadapted germplasm (donor) that cannot be used directly in breeding populations (exotic/wild species), and to transfer these traits into well-adapted genetic backgrounds (recipients) resulting in the development of an intermediate set of material which can be used readily by the plant breeders in specific breeding programmes to develop new varieties with a broad genetic base. It is the promising link between genetic resources and breeding programs. The success of any crop improvement program depends on the availability of sufficient genetic variability, but this variability must be in conventionally usable form.

Generally, pre-breeding work with the following objectives;

1) Reduce genetic uniformity in crops through the use of a wider pool of genetic material,

2) Identification of desirable traits/genes and their subsequent transfer,

3) Improved parental stocks which can be readily utilized within breeding programs,

4) Identify potentially useful genes in a well-organized and documented gene bank

Why Pre – breeding?

Pre-breeding is necessary, if the target genes are available only in gene bank accessions those are not well-adapted to the target environment, closely related wild species that are easily crossable and more distant wild species which are more difficult to cross. Though the availability of sufficient genetic variability determines the success of any crop improvement program, variability must be in conventional usable form. The replacement of highly diverse local cultivar and landraces by genetically uniform modern varieties led to increased genetic vulnerability for pests and diseases. The pre- breeding was used to adapt diverse kinds of germplasm to new genetic backgrounds and new geographic locals. The direction to involve pre-breeding is based on the expected efficiency, outcome and efficacy of ultimately moving the target traits into cultivars for farmers and source of desired gene. The replacement of highly diverse local cultivar and landraces by genetically uniform modern varieties led to increased genetic vulnerability for pests and diseases (Jain and Omprakash, 2019). So, pre-breeding is required because of limited genetic base, reduction of biodiversity, genetic uniformity which increase genetic vulnerability for pest and disease, effect of climate change and evolving of new pests.

Current limited genetic base of agriculture today is apparent a threat to food security.

- Reduction of Biodiversity: genetically uniform modern varieties are replacing the highly diverse local cultivars and landraces in traditional agro-ecosystems.

- Genetic uniformity: Increases genetic vulnerability for pests and diseases.
- The effects of climate change: search for new genes/traits for better adaptation.
- Evolving pest and pathogen populations: motivating plant breeders to look for new sources of resistance in gene banks.

Pre- breeding approaches

1. Characterization of landrace populations
2. Introgression of new traits
3. Creation of polyploidy
4. Development of new plant breeding techniques
5. Distant/ Wide hybridization
6. Applications of doubled haploids
7. Use of Gene pool and exotic germplasm

Breeding procedures

Breeding methods used for genetic enhancement are slightly different from those which are used in traditional breeding. The breeding methods/procedures which are commonly used for genetic enhancement include back cross, convergent improvement and marker – assisted backcross.

1. Back cross method:

Back cross is widely used for introgression and incorporation of desirable genes from exotic germplasm and wild species into well adapted cultivars. Introgression refers to transfer of one or a few alleles from exotic stocks to adapted breeding populations. It is used for genetic enhancement of both self and cross pollinated species. It is used for transfer of both oligogenic and polygenic traits. It is more successful when the character under transfer has high heritability.

2. Convergent Improvement:

In this method two genotypes are selected for crossing. The main objective of this scheme is to improve both the lines simultaneously. It is used for genetic enhancement of both self and cross pollinated species.

3. Marker – assisted backcross method:

Indirect selection for a desired plant phenotype on the basis of banding patterns of linked DNA (molecular) markers is known as marker assisted selection. This method permits identification of recessive alleles even in heterozygous condition and thus speeds up the progress of crop improvement. It requires sophisticated and well equipped laboratory to initiate work on marker assisted selection. It is very expensive method of crop improvement.

Major applications of pre-breeding in crop improvement:

There are major four applications of pre-breeding:

(1) Broadening the genetic base, to reduce vulnerability

(2) Identifying traits in exotic materials and moving those genes into material more readily accessed by breeders

(3) Moving genes from wild species into breeding populations when this appears to be the most effective strategy and

(4) Identification and transfer of novel genes from unrelated species using genetic transformation techniques.

The adoption of pre-breeding facilitates the efficiency and effectiveness of crop improvement programmes by enabling increased access to, and use of, genetic variations conserved in gene banks.

The Gene Pool Concept:

"The gene pool is the total genetic variation in the breeding population of a species and closely related species capable of crossing with it'. The gene pool of a crop is made up of botanical varieties, landraces, inbred lines, ancient landraces, obsolete and modern cultivars, related wild species, subspecies, and weedy companion species (Haussmann *et al.*, 2004).

- Primary gene pool (GP1): Intermating is easy and leads to production of fertile hybrids. It refers to same species cultivated and wild.
- Secondary gene pool (GP2) : It leads to partial fertility on crossing with different species than the cultivated
- Tertiary gene pool (GP3): It leads to production of sterile hybrids on crossing with more distantly related
- Quaternary gene pool (GP4): It refers to crop cultivars that have been developed through biotechnological approaches. It includes crossing with unrelated plant species and/or other organism

Challenges to adopt pre-breeding:

Lack of characterization, evaluation of genetic diversity, documentation of data-with lack/ false data of accession it is not possible to use this accession in the pre-breeding. This infers the urgent need of collection, characterization and documentation of wild species due to increased likelihood of extinction for narrowly adapted and endemic species.

a. Knowledge gap of the genetic diversity, extensive knowledge about genetic diversity of individual is essential to use accessions in pre-breeding.
b. Inter species cross incompatibility is the major factor which limits the use of different species in transferring gene of importance across species.
c. Strong breeding program and funding resource.
d. Linkage drag-separating desirable gene from undesirable difficult and time consuming

Conclusion

Pre-breeding is gaining importance in most crop improvement (such as wheat, maize and common bean) due to limited genetic variability is available in cultivated germplasm. It has been playing great role in continuous supply of useful variability from promising landraces and wild relatives to the breeding pipeline. Using crop wild relatives in crop improvement is much more difficult than breeding with domesticated varieties, but pre-breeding converts them in more readily crossable with modern and elite varieties. Linkage drags associated with exploiting of wild relative makes pre- breeding activities challenging. To overcome this and facilitate targeted transfer of useful genes for genetic enhancement, genome-assisted pre-breeding will be useful. Pre-breeding leads to broadening genetic base population and produce lines which could be used as parents in developing improved varieties, while the traditional breeding targeted in development of improved varieties with narrow genetic base and its end product is commercial cultivation. Generally, pre- breeding is fundamental for the success of breeders in developing crop varieties.

Reference

Haussmann, B.I.G., Parzies, H.K., Prester, T., Susic, Z. and Miedaner, T. (2004). Plant genetic resources in crop improvement. Plant Genetic Resources; 2(1): 3-21.

Jain, S.K. and Omprakash. 2019. Pre-breeding: A Bridge between Genetic Resources and Crop Improvement. *Int.J.Curr. Microbiol. App. Sci*. 8(02): 1998-2007.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

BANANA FIBRE: AN IN-DEPTH EXPLORATION

Article ID: AG-VO4-I12-63

N.V.S.Supriya[1*]

[1] Ph.D.scholar, Department of Fruit Science, Dr. YSRHU, College of Horticulture, Venkataramannagudem, A.P, India

*Corresponding Author Email ID: supriyanedunuri29@gmail.com

Introduction

Banana fibre, derived from the pseudostems of banana plants, is an ancient yet underappreciated natural fibre with a wide range of uses and significant environmental advantages. This fibre is predominantly extracted from the banana plant's pseudo-stem, which is the stalk-like structure that supports the plant's fruit. Known for its strength, durability, and eco-friendly properties, banana fibre is being increasingly recognized as a sustainable alternative to synthetic and other natural fibres in a variety of industries. This article will delve into the origin, extraction process, properties, uses, and benefits of banana fibre.

Origin and Cultivation of Banana Fibre

The banana plant (Musa spp.) is native to Southeast Asia but is now cultivated in tropical and subtropical regions around the world. The plant itself is herbaceous, meaning it has no woody trunk, and it is the pseudostem (the outer part of the stalk) that is utilized for extracting banana fibre. This plant is usually grown for its fruit, but after harvesting the bananas, the pseudostems are often discarded as waste. However, these discarded pseudostems are a valuable resource for extracting banana fibre, which has been traditionally used in many countries, especially in Asia.

Banana fibre is particularly abundant in countries such as India, Japan, the Philippines, and Nepal. The fibre is extracted from different species of banana plants, including *Musa balbisiana* (used primarily in the Philippines and India), *Musa acuminata*, and *Musa* × *paradisiaca*. In many cultures, the banana plant is an integral part of both the economy and the local ecosystem, as it can be cultivated in a variety of soil conditions and offers numerous uses beyond just its fruit.

Extraction Process of Banana Fibre

The process of extracting banana fibre involves several steps, beginning with the harvesting of the banana pseudostem. The pseudostems are cut into smaller sections to make extraction more manageable. These sections are then peeled to remove the outer layers, revealing the inner layers of the stalk from which the fibre is extracted. The fibre itself is generally located in the vascular bundles of the pseudostem.

Once the outer layers are removed, the inner layers of the pseudostem are subjected to various processes to separate the fibres from the pulp. This can be done manually, through a method known as retting, where the cut pieces of the pseudostem are soaked in water for several days. This natural fermentation process helps to break down the non-fibrous material, allowing the strong, long fibres to be separated more easily.

Alternatively, mechanical extraction methods can also be employed, such as using a decorticating machine that strips away the fibres from the stem more efficiently. Once extracted, the fibres are washed, dried, and sorted according to their length and quality. Depending on the intended use, the fibres may be further processed, spun into yarns, and dyed.

Properties of Banana Fibre

Banana fibre has several unique properties that make it an attractive option for both traditional and modern applications. Some of the key properties of banana fibre include:

1. **Strength and Durability**: Banana fibre is known for its remarkable tensile strength, making it an excellent material for producing robust textiles, ropes, and other products that require durability.
2. **Lightweight**: Despite its strength, banana fibre is relatively lightweight, making it an ideal material for clothing and other textile products.
3. **Biodegradability**: As a natural fibre, banana fibre is fully biodegradable, unlike synthetic fibres such as polyester, which can persist in the environment for hundreds of years. This makes banana fibre a highly sustainable and eco-friendly alternative.
4. **Absorbency**: Banana fibre is naturally absorbent, which makes it suitable for applications in the textile industry, particularly for garments and fabrics that need to handle moisture efficiently.

5. **Eco-friendly Dyeing**: Because of its porous nature, banana fibre can be dyed easily using natural or synthetic dyes, which enhances its versatility in producing a wide range of products in different colours.
6. **Texture and Appearance**: Banana fibre is often described as having a natural sheen, which is sometimes compared to silk, though its texture is coarser. This aesthetic feature makes it particularly desirable for high-end textiles and handicrafts.

Uses of Banana Fibre

Banana fibre has a broad spectrum of applications, ranging from traditional uses to modern technological innovations. Its versatility, strength, and sustainability make it ideal for a range of industries.

Textiles and Fashion

Historically, banana fibre has been used to make traditional garments, especially in Asian cultures. In Japan, for example, a fabric known as *banana silk* is created from the fibre, which is used to produce lightweight, breathable clothing. In India and Nepal, banana fibre has long been used for making sarees, mats, and bags. In these regions, the production of banana fibre textiles is deeply intertwined with traditional artisanal practices.

In the modern era, designers and textile manufacturers have begun to take a renewed interest in banana fibre due to its eco-friendly properties. As the fashion industry increasingly moves toward sustainability, banana fibre is seen as a potential alternative to synthetic fibres, such as nylon and polyester, which have significant environmental impacts.

Rope and Twine Production

Due to its strength and durability, banana fibre has long been used to make ropes and twines. In rural communities, banana fibre ropes are used for agricultural purposes, including tying crops and animals. This traditional application has remained important, especially in developing regions where banana plants are abundant.

Paper Production

Banana fibre is also used in the production of paper, especially in regions where banana plants are abundant. The fibre is processed into pulp and then used to create handmade paper products. This paper is often prized for its unique texture and appearance and is used in a variety of applications, from stationary to packaging materials.

Eco-friendly Products

Given the growing emphasis on environmental sustainability, banana fibre is increasingly being used in the production of eco-friendly products such as biodegradable bags, composites, and environmentally-conscious packaging. As industries seek alternatives to plastics, banana fibre presents a viable option, especially since it is renewable and decomposes naturally.

Environmental Benefits of Banana Fibre

Banana fibre offers numerous environmental benefits, making it a sustainable choice for industries looking to reduce their ecological footprint. These benefits include:

1. **Reduction in Agricultural Waste**: The banana plant is typically discarded after the fruit is harvested, leading to significant waste. By utilizing the pseudostem to extract fibre, banana farming can become more economically viable, as farmers can generate additional revenue from what would otherwise be waste.
2. **Sustainable Material**: Unlike synthetic fibres, which are derived from petrochemical resources, banana fibre is a natural product that requires minimal processing and has a minimal environmental impact. This makes it a much more sustainable alternative to plastic-based materials.
3. **Biodegradability**: Banana fibre is fully biodegradable, unlike synthetic fibres like nylon or polyester, which can take centuries to decompose. This makes banana fibre a far better option from an environmental standpoint, particularly when used in applications such as textiles and packaging.
4. **Reduced Carbon Footprint**: The carbon footprint associated with producing and processing banana fibre is much lower than that of synthetic fibres. As a plant-based material, banana fibre absorbs carbon dioxide during its growth, and its production process does not rely heavily on chemical processes or energy-intensive machinery.

Challenges and Future Prospects

While banana fibre offers numerous advantages, there are still some challenges to its widespread adoption. The extraction process can be labor-intensive, especially in regions where manual retting is the primary method used. Additionally, while the global demand for eco-friendly materials is growing, banana fibre is still considered a niche product, and scaling up production could require significant investment in infrastructure and technology.

However, with growing awareness of the environmental issues posed by synthetic fibres, there is significant potential for banana fibre to become a mainstream material in the textile, fashion, and packaging industries. Ongoing research into the properties of banana fibre and advancements in processing technologies are likely to further expand its range of applications.

Conclusion

Banana fibre is an extraordinary natural material with numerous benefits that position it as an eco-friendly alternative to synthetic fibres. Its strength, durability, biodegradability, and versatility make it suitable for a wide array of applications, from traditional garments to modern eco-friendly products. As the world moves toward more sustainable solutions, banana fibre holds considerable promise in reducing our reliance on plastics and other harmful materials, offering both economic and environmental benefits. Its potential for use in a variety of industries makes it a valuable resource in the pursuit of a more sustainable and circular economy.

Volume: 04 Issue No: 12

ROLE OF GUT MICROBIOME IN SILKWORM GROWTH AND PRODUCTIVITY

Article ID: AG-VO4-I12-64

[1]Dr. S. Susikaran*, [1]Dr. Allwin, [1]B. Karthickmani Bharathi, [1]Dr. P. Balasubramaniam and [2]G. Ragothuman

[1]Tamil Nadu Agricultural University, Coimbatore – 641 003. Tamil Nadu, India.

[2]Coconut Development Board, Centre of Excellence for Coconut, DSP Farm Dhali Udumalpet Tiruppur – 642 112. Tamil Nadu, India.

*Corresponding Author Email ID: susi.agri@gmail.com

Introduction

The gut microbiome has become a subject of immense interest across various biological fields given its profound influence on the health, development and performance of host organisms. This interest extends not only to humans and larger animals but also to insects like the silkworm, *Bombyx mori*L. The gut microbiome of silkworms comprising a diverse community of microorganisms such as bacteria, fungi and viruses which plays a crucial role in multiple physiological processes including digestion, immune function, growth and silk production.

Sericulture or silk farming has a deep historical significance *i.e.*, particularly in countries like China, India and Japan. In recent years, research has revealed that manipulating the gut microbiome of silkworms can enhance their health improve silk yield and reduce susceptibility to diseases. This article explores the structure of the silkworm gut microbiome, its essential functions and the growing body of evidence supporting its pivotal role in sericulture.

Silkworm Gut Microbiome: Composition and Structure

The gut of the silkworm has a specialized environment that houses a complex community of microorganisms. This microbiome is dynamic and shaped by various factors including the insect's developmental stage, diet, rearing environment and genetic background.

Key Microbial Communities

- **Bacteria:** The bacterial population in the silkworm gut is the most studied group within the microbiome. Key bacterial phyla found in the silkworm gut include Firmicutes, Proteobacteria and Bacteroidetes. Specific genera like *Enterococcus*, *Lactobacillus*, *Staphylococcus* and *Bacillus* dominate the gut and these bacteria are believed to play critical roles in digestion and immune function.
- **Fungi:** While less studied than bacteria, fungal species also inhabit the silkworm gut. Fungi particularly yeasts assist in breaking down complex sugars and polysaccharides in the mulberry leaves, the primary diet of the silkworm. Fungi may also contribute to the gut's nutrient absorption processes.
- **Viruses:** In addition to bacteria and fungi, viruses are present in the gut microbiome, some of which are symbiotic and beneficial while others viruses may be deletorious to the host. For instance, the *Bombyx mori* nucleopolyhedrovirus (BmNPV) is a pathogenic virus affecting silkworms but not all viruses are detrimental; some play regulatory roles in microbial populations.

Variation in Microbiome Composition

The composition of the gut microbiome can vary depending on multiple factors:

1. **Developmental Stage:** The gut microbiome evolves as the silkworm progresses through different developmental stages from the larval to the pupal and adult stages. The microbiome shifts to accommodate the changing dietary needs and physiological functions of the silkworm at each stage.
2. **Diet:** The microbiome is heavily influenced by diet, particularly the type and quality of mulberry leaves consumed. The bacterial populations in the gut adjust to optimize the breakdown of mulberry leaves and facilitate nutrient absorption.
3. **Environment and Rearing Conditions:** Rearing practices such as the cleanliness of the environment and the use of antibiotics can influence the diversity and abundance of gut microbes. Antibiotic use in particular, can have profound effects on microbial populations by disrupting beneficial bacteria.
4. **Geographic and Genetic Variations:** Silkworm strains from different regions or genetic lines exhibit distinct gut microbiome compositions thereby possibly reflecting adaptation to local environments or specific rearing practices.

Functions of the Gut Microbiome in Silkworms

The gut microbiome serves several crucial functions in silkworms thus affecting their growth, health and productivity. Understanding these roles highlights the importance of the microbiome for optimizing sericulture practices.

1. Digestion and Nutrient Absorption

The primary function of the silkworm gut microbiome is to aid in digestion and nutrient absorption. Mulberry leaves which make up the staple diet of silkworms are rich in polysaccharides, cellulose and other complex carbohydrates that the silkworm alone cannot fully digest. Gut bacteria produce enzymes that break down these complex molecules into simpler forms that the silkworm can absorb and use for energy and growth.

- **Cellulose and Polysaccharide Degradation:** Microbes in the silkworm gut particularly certain strains of bacteria and fungi, produce cellulases and other enzymes that break down cellulose and polysaccharides in mulberry leaves. Without these microbial contributions, the silkworm would be unable to extract sufficient energy from its diet.
- **Nitrogen Fixation and Synthesis of Amino Acids:** Some gut bacteria are involved in nitrogen fixation and the synthesis of essential amino acids. These microbial activities enhance the nutritional value of the mulberry leaves thereby supporting the silkworm's growth and the synthesis of proteins including the fibroin and sericin proteins that make up silk.

2. Immune Function and Disease Resistance

The gut microbiome plays a key role in bolstering the immune system of silkworms. Just as in other animals, beneficial microbes in the silkworm gut help to outcompete harmful pathogens by occupying niches and producing antimicrobial compounds. The microbiome also interacts with the silkworm's immune system to enhance its ability to fight off infections.

- **Protection against Pathogens:** Beneficial bacteria in the gut produce antimicrobial peptides (AMP's) and other bioactive compounds that inhibit the growth of pathogens like *Staphylococcus aureus* and *Escherichia coli*. These bacteria also prevent accumulation of deletorious microbes by competing for resources and spaces within the silkwormgut.
- **Stimulation of the Immune Response:** Certain microbes can stimulate the silkworm's innate immune system thus enhancing its ability to mount a defense against invading

pathogens. For example, *Lactobacillus* species have been shown to activate immune pathways in silkworms thereby increasing their resistance to infections.

3. Growth and Development

The gut microbiome is instrumental in regulating the growth and development of silkworms. Research has shown that silkworms reared with a healthy, balanced microbiome exhibit faster growth rates, reach larger sizes and produce higher-quality silk compared to those with disrupted microbiomes.

- **Enhanced Growth Rates:** Gut bacteria influence growth by facilitating better nutrient uptake and supporting the synthesis of vitamins and growth-promoting compounds. Probiotic treatments in silkworms have been linked to improved weight gain and faster maturation.
- **Pupal Weight and Silk Production:** The gut microbiome has a direct impact on the quality and quantity of silk produced by silkworms. Studies have demonstrated that silkworms with a well-balanced gut microbiome tend to have heavier pupae and produce more robust silk cocoons. Probiotic supplementation has been explored as a way to boost silk production.

4. Stress Tolerance

The gut microbiome also plays a role in helping silkworms cope with environmental stresses such as temperature fluctuations, oxidative stress and exposure to toxins. By modulating stress-related metabolic pathways, beneficial gut microbes enhance the resilience of silkworms under adverse conditions.

- **Oxidative Stress Mitigation:** Certain microbes in the silkworm gut have antioxidant properties which help protect the host from oxidative damage caused by stressors such as heat or chemical exposure. This can lead to better survival rates under challenging rearing conditions.
- **Detoxification of Harmful Compounds:** The gut microbiome contributes to detoxifying harmful substances that the silkworm may ingest along with its diet. Microbes can metabolize or sequester toxins thereby preventing them from causing damage to the host.

Conclusion

The gut microbiome is essential to the health, growth and overall productivity of silkworms. Its functions in digestion, immune response, growth regulation and stress tolerance make it a key factor in the success of sericulture. By studying and managing the gut microbiome, sericulturists can boost silkworm performance improve silk quality and promote more sustainable silk production.As research in this field advances, the gut microbiome will likely become an even more important tool in the future of sericulture.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

CUSTOMIZED FERTILIZERS AND ITS IMPACT ON NUTRIENT AVAILABILITY AND UPTAKE IN CROPS

Article ID: AG-V04-I12-65

Annappa, N. N[1] and Krishna Murthy, R[2]

[1]Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, UAS, Bangalore-65

[2]Professor and Scheme Head, AICRP on STCR, Department of Soil Science and Agricultural Chemistry, UAS, Bangalore-65

*Corresponding Author Email ID: annappann61@gmail.com

Abstract

Customized fertilizers are tailored nutrient solutions designed to meet specific crop needs and soil conditions, enhancing nutrient efficiency and sustainability in agriculture. Unlike conventional fertilizers, they optimize nutrient availability, reduce losses through leaching and runoff, and support balanced soil fertility and microbial activity. By aligning nutrient supply with crop demands, customized fertilizers improve uptake efficiency, boost yields, and address nutrient deficiencies. Widely used in precision farming and high-value crops, they also benefit staple crop production, enhancing food security. Despite challenges like cost and limited adoption, advancements in digital agriculture promise broader accessibility, positioning customized fertilizers as a key tool for sustainable farming.

Keywords: Customized fertilizers, nutrient efficiency, precision farming, sustainable agriculture, nutrient uptake.

Introduction

In modern agriculture, achieving high nutrient efficiency while maintaining environmental sustainability is a critical objective. Customized fertilizers have emerged as an innovative solution to this challenge. These fertilizers are specifically formulated to cater to the unique nutrient requirements of crops. They also consider the characteristics of soil types and regional climatic conditions. By tailoring nutrient compositions, customized fertilizers enhance nutrient availability and uptake by plants. This approach improves input efficiency, ensuring that crops receive the right nutrients in the right amounts. It minimizes nutrient losses to the environment, reducing risks such as leaching and runoff. Consequently, this technology contributes to sustainable farming practices. Customized fertilizers thus represent a significant step forward in addressing the dual goals of productivity and environmental conservation in agriculture.

What are Customized Fertilizers?

Customized fertilizers are bespoke nutrient blends formulated based on soil health, crop requirements, and environmental conditions (**Farooq *et al*., 2022**). Unlike conventional fertilizers, which provide fixed nutrient ratios, these fertilizers are designed to address specific deficiencies and optimize the nutrient balance in a given field. By delivering the right nutrients at the right time and in the right quantities, customized fertilizers promote efficient nutrient uptake and minimize losses.

Impact on Nutrient Availability

1. **Enhanced Soil Nutrient Balance**
    - Customized fertilizers provide precise amounts of nutrients, reducing over-application and soil nutrient imbalances.
    - Incorporation of slow-release or controlled-release formulations ensures prolonged nutrient availability.
2. **Reduced Nutrient Losses**
    - Reduced leaching of nitrogen and phosphorus, mitigating environmental risks like groundwater contamination and eutrophication.
    - Minimizes volatilization and denitrification losses.
3. **Improved Soil Microbial Activity**
    - Balanced fertilization encourages beneficial microbial activities, enhancing nutrient mineralization and availability.

Impact on Nutrient Uptake by Crops

1. **Increased Uptake Efficiency**
    - Nutrients are supplied in forms and ratios that align with crop demand during specific growth stages.
    - Reduced nutrient competition or antagonism (e.g., optimal N:P: K ratios preventing imbalances).

2. **Improved Growth and Yield**
    - Adequate nutrient supply enhances root development, increasing the plant's ability to uptake nutrients.
    - Better nutrient uptake contributes to improved physiological functions like photosynthesis and protein synthesis.
3. **Mitigation of Deficiency Symptoms**
    - Customized formulations address specific nutrient deficiencies, leading to healthier crops with optimal yields.

This tailored approach to nutrient delivery boosts root development, enhances chlorophyll synthesis, and improves overall plant growth, resulting in higher yields and superior crop quality. Additionally, customized fertilizers prevent over-application of nutrients, mitigating risks of soil and water pollution caused by nutrient runoff, thereby reducing the environmental footprint. By adapting to regional needs, such as saline soils or micronutrient deficiencies, they provide targeted solutions that cater to diverse agricultural ecosystems, making them an essential tool for sustainable farming (**Bhattacharya *et al*., 2019**).

Applications in Modern Agriculture

Customized fertilizers are highly advantageous in precision farming systems. In such systems, soil testing and crop modeling provide data to guide nutrient application. This ensures that fertilizers are applied in the right quantities and at the right time. These fertilizers are becoming increasingly popular in high-value crops like fruits, vegetables, and flowers. In these crops, precise nutrient management significantly influences quality and marketability. Customized fertilizers are also essential for promoting balanced nutrition in staple crops. They help optimize nutrient use to maximize yield and nutritional value. This plays a critical role in ensuring food security, particularly in regions with nutrient-depleted soils. Overall, customized fertilizers enhance agricultural efficiency while addressing the diverse needs of modern farming systems.

Challenges and Future Directions

While the benefits of customized fertilizers are significant, challenges such as high production costs, limited awareness among farmers, and logistical hurdles in distribution need to be addressed. Advances in digital agriculture, including soil sensors and AI-based nutrient recommendations, are expected to make customized fertilizers more accessible and cost-effective.

Conclusion

The shift toward customized fertilizers represents a transformative step in modern agriculture. By aligning nutrient supply with plant needs, these innovative fertilizers enhance nutrient use efficiency, reduce environmental footprints, and support sustainable crop production systems. As the agricultural sector embraces precision technologies, customized fertilizers are set to become an integral part of the global effort to ensure food security and environmental sustainability.

References

Farooq, F., Choudhary, R.K., Kumawat, S.N., Gulshan, T., Singh, B. and Bhadu, A., 2022. Customized fertilizer: a key for enhanced crop production. *International Journal of Plant & Soil Science*, pp.954-964.

Bhattacharya, P., Sengupta, S. and Halder, S., 2019. Chapter-5 Customized, fortified and nano enabled fertilizers-prioritizing and profiteering sustainability in agriculture. *Chief Editor Dr. RK Naresh*, *69*.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

PARTICIPATORY PLANT BREEDING

Article ID: AG-V04-I12-66

***K.S.Vijay Selvaraj[1], A. Bharathi [2], S. Suganthi[2], S. Babu[2] and D. Dhanasekaran[2]**

1 Vegetable Research Station, TNAU, Palur, Cuddalore, Tamil Nadu

2 Agricultural College and Research Institute, TNAU, Vazhavachanur, Tiruvannamalai, Tamil Nadu, India

*Corresponding Author Email ID: ksvijayselvaraj@gmail.com

Introduction

It is an approach involving different participants including scientists, farmers, cooperatives, vendors, traders, processors, government and non government organizations in plant breeding research. (Sperling et al., 2001).It is considered as participatory' because of mixture of different people's from different organizations.These different actors participate in setting PPB goals, setting breeding priorities, selecting genotypes from a heterogeneous and population, helping in evaluation and selection of cultivars, releasing and popularizing high yield cultivars and helping in seed multiplication and distribution.(MC Guire et al.,2003).Significant changes in cultivars release procedure and seed multiplication system.In PPB, time for testing to release of cultivar is shorter than conventional breeding-led participatory Plant Breeding.

PPB GROUPED IN FOLLOWING CATEGORIES:

It describes a situation when farmers are asked to join in PPB activities which have been initiated managed and executed by formal breeding programs such as National Agricultural Research System (NARS) or International Agricultural Research Centre (IARC).

Farmer-led Participatory Plant Breeding

It describes a situation when scientists and/or development workers seek to contribute or support farmers own controlled, managed and executed breeding systems. Scientists can support their own varietal selection and seed system.

GOALS OF PPB:

First activity is diagnostic survey,

It allows effective discussion between breeders and farmers and also enables breeders to better understand,

1. Agricultural problems of the local farming conditions,
2. Farmers crop management practices,
3. Farmers specific needs and preferences.

GOALS:

- Increase production and productivity in non-commercial crops in environment that are unpredictable and under Abiotic/Biotic stress.
- Enhance biodiversity and increase germplasm access to local farmers.
- Increase farmer skills to speed up farmer selection and seed production efforts.

TYPES OF PARTICIPATION:

The types of participation in PPB are*:*

1) Conventional

In this approach, there is no farmer participation.

2) Consultative

Farmers are consulted at every PPB stage but the breeder makes the decisions. In this approach, farmers participate in making joint selections with breeder.

3) Collaborative

- In this approach, decisions are made jointly by farmer and breeder.
- Farmers and breeders know each other regarding selection criteria, and their priorities for their research through two way communication.

4) Collegial Participation

- Farmers grow genotypes in their farm fields and make their own plant or genotype selections.
- Farmers make decisions in group or individually but in organized communication with breeder.
- Farmers voluntarily supply some of the seeds of selected genotypes to breeder for further evaluation and seed multiplication.

5) Farmer experimentation

- In this breeders do not participate in selection of genotypes or in any farmer's research activities.
- Farmers make decisions in group or individually without organized communication with breeders.

STAGES OF PARTICIPATION:

Set the breeding objectives/targets.

- Generate genetic variability from local landraces or using collections for testing with complementary characteristics.
- Determine the approach (consultative/collaborative).
- Evaluate cultivar and discard inferior genotypes.
- Collaborating with seed system.

IMPACTS OF PPB

1) Higher adoption rate of PPB products such as new cultivars, agronomic and crop protection practices.

2) Improved cultivars acceptable by farmers for highly stressed marginal areas.

3) In remote areas of developing countries where soil is degraded and drought is a major production problem, new varieties developed and immediate adoption of new technologies and yield increase is achieved.

4) Significant changes in cultivars release procedure and seed multiplication system. In PPB, time for testing to release of cultivar is shorter than conventional breeding.

Reference

Iastate.pressbooks.pub

www.agritechportal,tnau.ac.in

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

ANAEROBIC GERMINATION AND SUSTAINABLE DIRECT SEEDING IN RICE (*ORYZA SATIVA* L.)

Article ID: AG-VO4-I12-67

Shanthi, P[1*], M.Umadevi[2] and T.Kalaimagal[1]

[1]Department of Genetic and Plant Breeding, CPBG, TNAU, Coimbatore -3.Tamil Nadu, India

[2]Department of Rice, CPBG, TNAU, Coimbatore -3. Tamil Nadu, India

*Corresponding Author Email ID: shanthipbg@tnau.ac.in

Introduction

Rice, the second largest cereal crop globally, dominates Asian agriculture with an annual production of 510 million tones. Unanticipated flooding presents a significant challenge to rice cultivation globally. Flooding during the germination and early growth stages can result in complete crop failure. Consequently, there is a necessity for rice varieties that exhibit tolerance to flooding during these critical phases. Farmers in India are adopting dry seed broadcasting technology for the practice of direct-seeded rice (DSR). However, this method poses significant risks to lowland rice cultivation, adversely affecting yield, growth, and germination. A study indicates that rice producers often encounter various challenges due to flooding stress, which can lead to issues such as persistent waterlogging and inundation during germination.

The adoption of direct-seeded rice (DSR) is significantly impeded by anaerobic germination (AG). In DSR conditions, AG plays a critical role in ensuring yield stability and adaptability, which is subsequently followed by the development of shoots and roots. Genotypes that exhibit tolerance to AG demonstrate rapid shoot growth, enabling them to reach the water's surface swiftly to access oxygen. Enhanced coleoptile development during submergence represents a vital morphological adaptation for these tolerant varieties. Nevertheless, the normal germination and growth of seedlings are considerably affected by the reduction in ATP production in anaerobic conditions. To support the growth of embryos and the elongation of coleoptiles in low-oxygen environments, certain rice cultivars have developed unique strategies, including improved starch metabolism.

At the initial seedling stage, an overabundance of water results in the crop experiencing submergence. This submergence diminishes air diffusion, thereby restricting the availability of O_2 and CO_2 in the submerged tissues. Consequently, this creates a hypoxic environment, characterized by oxygen levels falling below 21%, which is lower than the oxygen concentration found under normoxic conditions. Less O_2 condition, reduce the respiration and increase the fermentation leads to accumulation of several phytotoxic substances such as reduce iron (Fe^{2+}), Magnanese (Mn^{2+}) Hydrogen sulfide (H_2S), oxygen radicals and causes severe damage to plants.

During anaerobic germination, rice seedlings exhibited a greater elongation of coleoptiles compared to the emergence of roots. This process enables rice to withstand anoxic conditions, which are prevalent in the semiaquatic environments where rice was originally cultivated. Additionally, anaerobic germination facilitates the utilization of water for controlling weeds. The Japonica subspecies demonstrate a higher adaptability to germination in submerged conditions compared to other subspecies. There is a minimal correlation between germination under aerobic and anaerobic conditions, suggesting that their genetic regulation operates independently. Alcohol dehydrogenase (ADH) is an enzyme that plays a crucial role in the rate-limiting step of ethanol metabolism, which is essential for rice germination and growth in low oxygen stress environments.

During anaerobic germination, rice seedlings exhibited a greater elongation of coleoptiles compared to the emergence of roots. This process enables rice to withstand anoxic conditions, which are prevalent in the semiaquatic environments where rice was originally cultivated. Additionally, anaerobic germination facilitates the utilization of water for controlling weeds. The Japonica subspecies demonstrate a higher adaptability to germination in submerged conditions compared to other subspecies. There is a minimal correlation between germination under aerobic and anaerobic conditions, suggesting that their genetic regulation operates independently. Alcohol dehydrogenase (ADH) is an enzyme that plays a crucial role in the rate-limiting step of ethanol metabolism, which is essential for rice germination and growth in low oxygen stress environments.

Some rice varieties like Sahbhagi dhan, DRR42, DRR 44, CR dhan 201, CR dhan 203 and swarna were developed in India and had the tolerance to anaeraobic germination. This is one of the niche area need to focus more to develop the rice genotypes suitable for DSR in wet area and this also helps for complete mechanization of the rice.

Volume: 04 Issue No: 12

BIOCHAR: TRANSFORMING AGRICULTURE FOR A GREENER FUTURE

Article ID: AG-V04-I12-68

G. Sri Hari[1] and Ch. Durga Pavani[2*]

1. Ph.D. Research Scholar, Department of Genetics and plant breeding, Agricultural College, Bapatla, ANGRAU, AP, India

2. M.Sc. Research Scholar, Department of Genetics and plant breeding, Agricultural College, Bapatla, ANGRAU, AP, India

*Corresponding Author Email ID: pavanichittimoju99@gmail.com

Introduction

Agriculture lies at the heart of human civilization, yet modern farming is grappling with significant challenges: declining soil fertility, climate change, and the urgent need to feed an expanding global population. One innovative solution drawing attention is biochar, a centuries-old material that promises to revolutionize sustainable farming practices by enhancing soil health and productivity.

What is Biochar?

Biochar is a carbon-rich material made by heating organic waste-like crop residues, wood chips, or manure in the absence of oxygen, a process known as pyrolysis. This creates a black, charcoal-like substance that acts as a soil enhancer, boosting fertility and improving crop growth. Beyond its agricultural benefits, biochar helps sequester carbon and reduce greenhouse gases, making it a powerful tool for sustainable farming and environmental protection.

A Natural Boost for Soil

Healthy soil is the backbone of productive farming, and biochar offers a natural, sustainable way to improve its quality and performance:

- **Improves Soil Fertility**: Biochar helps retain essential nutrients, making them available to plants over a longer period. When combined with compost or fertilizers, biochar can enhance soil fertility even further.

- **Enhances Water Retention**: The porous structure of biochar acts like a sponge, holding water and preventing rapid drainage. This is especially beneficial in drought-prone regions where water conservation is critical.
- **Balances Soil pH**: In acidic soils, biochar can help neutralize the pH, creating a better environment for crops to grow.
- **Boosts Microbial Activity**: Soil microbes are essential for breaking down organic matter and cycling nutrients. Biochar provides a habitat for these microbes, promoting healthier soils.

A Climate-Friendly Solution

Biochar offers an innovative and effective approach to tackling climate change. Here's how it can help:

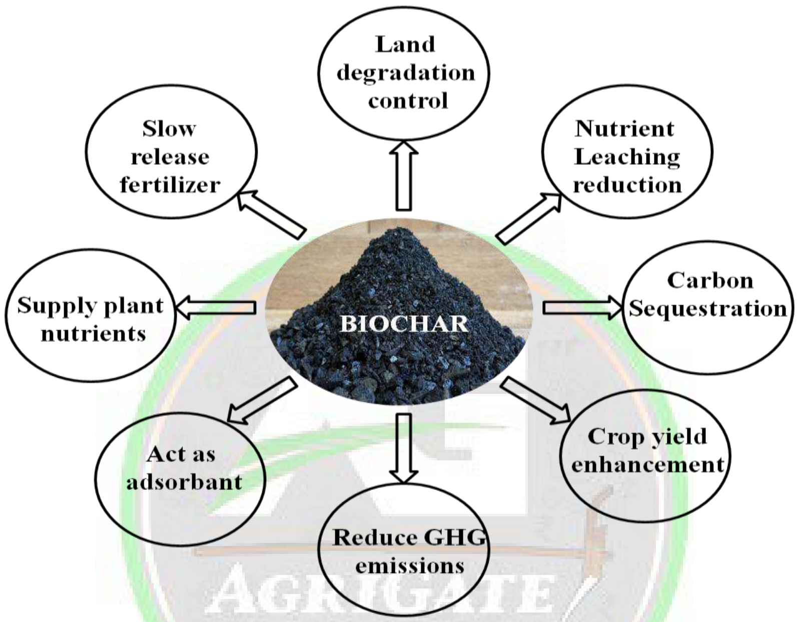
1. **Carbon Sequestration**: Plants absorb carbon dioxide (CO_2) from the atmosphere as they grow. By converting plant material into biochar and burying it in the soil, we can lock this carbon away for hundreds or even thousands of years, helping to reduce the concentration of greenhouse gases in the atmosphere.
2. **Reduces Methane and Nitrous Oxide Emissions**: Adding biochar to soil has been shown to lower the release of methane (CH_4) and nitrous oxide (N_2O), two potent greenhouse gases that contribute significantly to global warming.
3. **Sustainable Waste Management**: Producing biochar from agricultural and forestry waste prevents these materials from being burned or discarded, which would otherwise release CO_2 and other harmful pollutants into the atmosphere. This makes biochar a key player in reducing overall environmental impact.

How Farmers are Using Biochar

Farmers across the globe are discovering creative ways to integrate biochar into their practices:

- **In Crop Fields**: Biochar is mixed into the soil to enhance fertility, boost crop yields, and reduce the need for water and fertilizers, making farming more efficient and sustainable.
- **In Animal Farming**: It is added to animal feed or bedding to improve livestock health, enhance digestion, and reduce odors, benefiting both animals and the farm environment.

- **In Reforestation Projects**: Biochar is used to help restore degraded lands by improving soil quality, which allows trees and plants to grow better and faster in areas that have suffered from erosion or poor soil health.
- **In Organic Farming**: As a natural soil amendment, biochar aligns perfectly with organic farming principles, offering a chemical-free way to enrich the soil and promote sustainable farming practices.



Challenges and Future Potential

While biochar offers many advantages, there are challenges to its widespread adoption. One of the main obstacles is the need for specialized equipment to produce biochar, which can be costly for small-scale farmers. Additionally, the effectiveness of biochar can vary depending on factors like soil type and the crops being grown, meaning it may not always be a universal solution. However, the future of biochar remains promising. Technological advancements are making biochar production more efficient and affordable, while governments and organizations are beginning to offer incentives to support its use. With continued research and innovation, biochar has the potential to become a key tool in creating climate-resilient and sustainable agricultural systems, helping to address the dual challenges of feeding a growing population and combating climate change.

Why Biochar Matters

Biochar is more than just a farming tool-it represents a critical step toward a greener, more sustainable future. By improving soil health, boosting crop productivity, and sequestering carbon, biochar serves as a bridge between traditional agricultural practices and modern environmental solutions. For farmers, it offers a way to grow more with fewer resources, enhancing yields while reducing the need for water and fertilizers. For the planet, biochar provides an opportunity to combat climate change by capturing carbon and regenerating degraded land. With its wide-ranging benefits, biochar holds the promise of transforming agriculture into a more sustainable and climate-resilient industry.

Conclusion

Biochar offers a promising solution to both agricultural and environmental challenges. By improving soil health, boosting crop yields, and sequestering carbon, it provides a sustainable way to enhance farming practices while helping combat climate change. Though there are obstacles to its widespread adoption, ongoing advancements in technology and increased support for its use suggest that biochar has the potential to play a significant role in creating more resilient and sustainable agricultural systems for the future.

References

Jha, P., Biswas, A.K., Lakaria, B.L and Rao, A.S. (2010). Biochar in agriculture – prospects and related implications. *Current Science*. 99(9): 1218-1225.

Lakaria, B.L., Jha, P., Biswas, A.K., Patra, A.K and Chaudari, S.K. (2021). Protocol for Biochar Use in Indian Agriculture. ICAR-Indian Institute of Soil Science, Bhopal, Mp, 13p.

Yadav, S.P.S., Bhandari, S., Bhatta, D., Poudel, A., Bhattarai, S., Yadav, P., Ghimire, N., Paudel, P., Paudel, P., Shrestha, J and Oli, B. (2023). Biochar application: A sustainable approach to improve soil health. *Journal of Agriculture and Food Research*. https://doi.org/10.1016/j.jafr.2023.100498.

Volume: 04 Issue No: 12

ORGANIC FARMING AND ITS PRINCIPLE

Article ID: AG-V04-I12-69

***Mahendra Junjariya and Naresh Kumar**

Ph.D. Research Scholar, Department of Agronomy, Agriculture University, Jodhpur, india

*Corresponding Author Email ID: mahijunjariya@gmail.com

Introduction

Organic Agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved.

Principles of Organic Farming

The four principles of organic agriculture are as follows:

1. **Principle of health** - Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops that foster the health of animals and people.

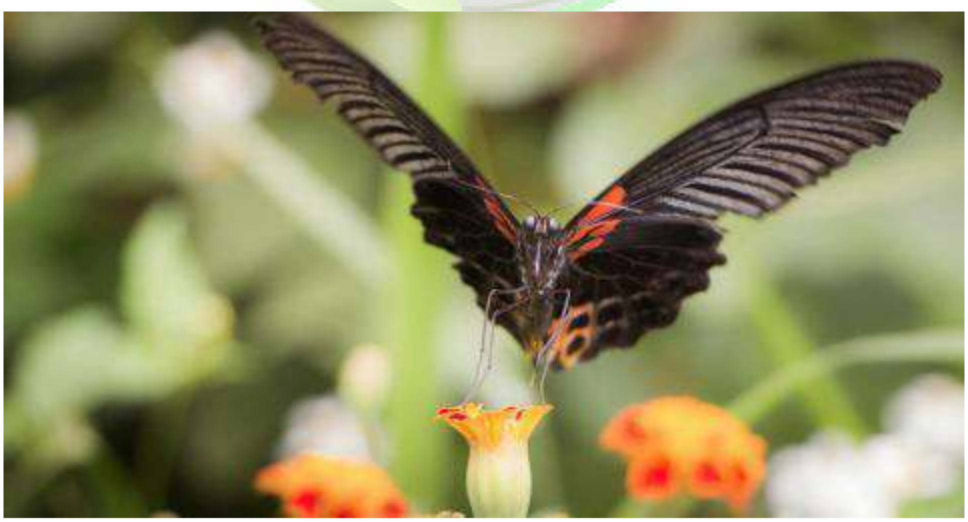
Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health.

The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings. In particular, organic agriculture is intended to produce high quality, nutritious food that contributes to preventive health care and well-being. In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

2. **Principle of ecology** - Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

This principle roots organic agriculture within living ecological systems. It states that production is to be based on ecological processes, and recycling. Nourishment and well-being are achieved through the ecology of the specific production environment. For example, in the case of crops this is the living soil; for animals it is the farm ecosystem; for fish and marine organisms, the aquatic environment.

Organic agriculture should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.



3. **Principle of fairness** - Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities. Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings.

This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties - farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty. It aims to produce a sufficient supply of good quality food and other products.

This principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behavior and well-being.

Natural and environmental resources that are used for production and consumption should be managed in a way that is socially and ecologically just and should be held in trust for future generations. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

4. **Principle of care** - Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Organic agriculture is a living and dynamic system that responds to internal and external demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being.

Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, care must be taken.

This principle states that precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture. Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time. Organic agriculture should prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones, such as genetic engineering. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

Advantages of Organic Farming

Economical: In organic farming, no expensive fertilisers, pesticides, or HYV seeds are required for the plantation of crops. Therefore, there is no extra expense.

Good return on Investment: With the usage of cheaper and local inputs, a farmer can make a good return on investment.

High demand: There is a huge demand for organic products in India and across the globe, which generates more income through export.

Nutritional: As compared to chemical and fertiliser-utilised products, organic products are more nutritional, tasty, and good for health.

Environment-friendly: The farming of organic products is free of chemicals and fertilisers, so it does not harm the environment.

Disadvantages of Organic Farming

Incompetent: The major issue of organic farming is the lack of inadequate infrastructure and marketing of the product.

Less production: The products obtained through organic farming are less in the initial years as compared to that in chemical products. So, farmers find it difficult to accommodate large-scale production.

Shorter shelf life: Organic products have more flaws and a shorter shelf life than that of chemical products.

Limited production: Off-season crops are limited and have fewer options in organic farming.

Types of Organic Farming

Organic farming is divided into two types, namely:

1. Integrated organic farming
2. Pure organic farming

Pure organic farming means avoiding all unnatural chemicals. In this process of farming, all the fertilisers and pesticides are obtained from natural sources such as bone meal or blood meal. Integrated organic farming includes the integration of pest management and nutrients management to achieve ecological requirements and demands.

Meaning and Importance of Organic Farming

Meaning of organic farming

System of farming that uses organic inputs like green manures, cow dung, etc., for cultivation.

Need of organic farming

- Excessive use of chemical fertilisers reduces the fertility of soil.
- Excessive use of chemicals has led to soil, water, and air pollution.
- To conserve ecosystem.
- To promote sustainable development.
- Inexpensive farming.
- Increased demand of organic products due to safety of food.

Benefits of Organic Farming

- Environment-friendly.
- Promotes sustainable development.
- Healthy and tasty food.

- Inexpensive process.
- It uses organic inputs.
- Generates income.
- Generates income through exports.
- Source of employment.
- Organic farming is more labour intensive. Hence, it generates more employment.

Limitations of organic farming

- Less output.
- Higher price.
- The lack of awareness.
- Organic products generally demand a higher price due to a higher demand.
- Shorter shelf life.
- Organic products have a shorter shelf life due to the absence of artificial preservatives.

Volume: 04 Issue No: 12

RESOURCE CONSERVATION TECHNOLOGIES FOR REDUCED WATER FOOTPRINTS AND HIGHER INPUT USE EFFICIENCIES

Article ID: AG-VO4-I12-70

***[1]Knight Nthebere and [2]Rajan Bhatt**

[1]National University of Lesotho, Maseru, Lesotho.

[2]PAU-Krishi Vigyan Kendra, Amritsar-143601, Punjab, India.

*Corresponding Author Email ID: knthebere@gmail.com

Abstract

The population is increasing at an alarming rate, which would be challenging to feed about 9 billion people by 2050. Adoption of traditional rice and wheat crop establishment methods are thought to be energy, water, labor, and capital intensive in the Indo-Gangetic Plains region of India with lesser-input use efficiency. Short-duration cultivars, timely transplanting of rice seedlings, precision land leveling, direct seeded rice, mechanical transplanting, soil matric potential-based irrigation scheduling, permanent beds, happy seeder, and other resource conservation technologies (RCTs) can help to sustain food production, reduce water, energy, and carbon (C) footprints in the region. However, their performance is not universally applicable and is site- and situation-specific. Thus, farmers are to consider these according to local conditions as to reap the full beneficial inputs with decreased C, water, and energy footprints in a more sustainable and climate-smart manner.

Keywords: Resource conservation technologies, Direct Seeded rice, Mechanical transplanting of Rice, food Security

Introduction

The rice-wheat cropping system (RWCS) is said to be the single greatest cropping sequence that has been adopted anywhere in the globe including China and Indo-Gangetic plains (IGP) of India in more than 24 million hectares currently. The IGP are located in India and stretch from the northwest in the state of Punjab to the east in the state of West Bengal. In addition, India (12.3 million ha), Nepal (0.5 million ha), Pakistan (2.2 million ha), and

Bangladesh (0.8 million ha) are adopting conventional RWCS. The majority of these lands belong to IGP (about 85 percent), and they produce almost half of South Asia's food grains. The long-term viability of RWCS in South Asia is in peril as a result of the adoption of ineffective crop establishment practices over a prolonged period of time, which has led to a number of problems related to the ecosystem's ability to maintain itself. Traditional puddling procedures developed rice on sandy soils. This was done to close soil pores and reduce drainage losses; however, sub-surface compaction hinders root growth of the next upland crop such as wheat. Thus, rice farming techniques require a lot of water, labor, capital, and energy, causing sustainability issues. Thus, South Asian experts have designed, tested, and advised RWCS farmers on how to increase land and water productivity and reduce carbon, water, and energy footprints. Zero-till farming, mulching, short-duration cultivars, laser land leveling, soil matric potential-based irrigation scheduling, bed planting, timely transplanting, crop diversification, and direct-seeded rice are the most crucial to achieving food and environmental security in a sustainable and climate-aware manner.

Resource Conservation Technologies

1. Zero Tillage

In Indo-Gangetic plains, the zero-tillage (ZT) wheat sowing method has been introduced in the maximal area. However, that was only the case subsequent to maintenance of all the crop residues, which led to an improvement in the physico-chemical soil attributes. Other soil properties were also improved because of ZT implementation. On the other hand, intensive tillage is likely to break down larger soil aggregates into smaller ones, thus, exposing organic materials that were previously buried to be utilized for microbe's survival for oxidation of matter as to produce carbon dioxide (Nthebere *et al*., 2023). It has also been observed that ZT farming improves several properties, which results in increased land productivity and an overall improvement in the farmers' standard of living.

2. Mulching

According to the IGP for the SA region, zero tillage (ZT) was implemented in the possible maximum area. Nevertheless, that was only the case after preservation of the overall crop residues, which resulted in an enhancement of the physico-chemical properties of the soil. ZT has also enhanced other soil properties in this region. Excessive tillage, on the other hand, is thought to disrupt soil aggregates meant to improve the soil structural stability, thus, exposing previously concealed organic matter for microbe's survival and oxidizing it, resulting in CO_2 liberation. There was an additional evidence that ZT increased a variety of soil attributes, which in turn benefited the land's productivity and the farmers' overall well-being.

3. Short Duration Rice Cultivars

Long-duration rice cultivars such as Pusa-44 are thought to yield more although their water requirements are significantly higher. In addition to that, these cultivars were susceptible for attack by insect pests and diseases, whereas short-duration rice cultivars such as PR-126 and PR-127 required less water for irrigation and encountered fewer problems with insect pests and diseases.

4. Date of Rice Transplanting

Rice seedlings that were planted in the month of May, needed increased amounts of irrigation as a result of the dry air in the surrounding environment, which absorbs a substantial amount of water through evaporation and, as a result, highlights the importance of regular irrigations for satisfying the plant's needs; this is quite a tough job in stressed places. Now, timely transplantation of seedlings after the 10th of June is recommended since, after that, the following months coincide with the monsoon rains, which moisten the dry air and, as a result, limit its moisture lifting capability. This, in turn, further reduces the frequency of irrigation and reduces water footprints.

5. Direct Seeding of Rice (DSR)

After realizing that puddling had a negative impact on overall water requirements and the structure of the soil, scientists developed, tested, and suggested a new method of rice establishment. This method is commonly known as direct seeded rice (DSR), and it is designed to be used in *Tar Vattar* circumstances. (Field capacity). DSR results in a considerable reduction in the expenditures associated with crop establishment, particularly in the Covid-19. The DSR, on the other hand, is suffering from a serious iron deficiency and, secondly, a substantially larger weed population, both of which need to be investigated. In addition, DSR is said to be adequate in medium to heavy textured soils, but it fails miserably in sandy soils, making the former a poor choice for this application.

6. Laser Land Leveling (LLL)

The LLL resource conservation technologies (RCT) is the most widely used in the region, and its implementation led to water conservation of approximately 30 percent without a corresponding reduction in crop production. In addition, it was observed that irrigation water productivity (IWP) increased by around 39% in rice fields, while at the same time, the cost of herbicide was reduced to approximately 13%. Without causing any decrease in yield, the LLL technology provides a tremendous amount of promise for improving water use efficiency (WUE) in rice. The only drawback of this RCT is the relatively expensive cost of the level-operating equipment. However, this problem can easily be solved with a custom hire service.

7. Permanent Beds

The bed planting method, also considered an essential RCT to lower water footprints by up to 20-30%, was initially explored for wheat in Mexico and later for rice. In areas with dense, impermeable soils, where inadequate aeration is a concern, bed planting may be a solution. Additionally, it was stated that the nitrogen (N) recovery, and hence the ultimate yields, were greater in beds (Table 1).

Table 1. Performance of bed-planted wheat over other establishment techniques

Establishment method in wheat	**Water productivity (g m^{-3})**		
	Direct seeded basmati rice	**Transplanted Basmati**	**Mean**
Conventional sown wheat	384.21	366.5	375.4
Bed planted wheat	388.0	366.4	377.2
Zero till wheat	374.6	359.4	367.0
Mean	382.3	364.1	

(Source: Brar *et al*. 2011)

This RCT suffers from temporal (time) effects (Table 2), as fresh beds are effective, however, as they age, re-shaping operations are required with a tractor and under the extra pressure exerted by the tractor tyres with the side slope of the beds pressed, resulting in compaction and poor root mass density. Fresh beds can work better in this case.

Table 2 Root mass density (mg cm^{-3}) of rice grown on fresh and permanent beds

Soil depth (cm)	**Fresh beds**	**Permanent beds**
0-5	2.078[a]	1.209[b]
5-10	1.524[a]	0.957[b]
10-15	0.359[a]	0.320[b]

15-20	0.149[a]	0.141[a]
20-25	0.041[a]	0.063[a]
25-30	0.036[a]	0.043[a]
0-30	***0.698***	***0.456***

(Source:Kukal *et al*. 2008)

8. Soil Matric Potential Based Irrigation

The amount of irrigation water saved as a result of this was reported to be anywhere from 11.1% to 30.7% during the years 2006 and 2010, which further helps to reduce water footprints, notably in rice. Tensiometers also take care of the soil texture, which is important because it demands a greater number of irrigations be applied to sandy soils. The tensiometer was able to stop the water from escaping through drainage, which resulted in a decrease in its potential for water recharging. According to reports, this technique is highly effective in areas where water logging conditions provide a challenge, such as South-Western Punjab. The tensiometer is a water footprint-cutting technique that is particularly useful in rice-based cropping sequences. It has been promoted in the region by various extension organizations, but even so, it has not been adopted to the levels that were expected and a number of variables, both direct and indirect have been recognized as contributing factors.

9. Crop Diversification

The only option to effectively improve the deteriorating soil health and the farmers' ability to make a living is to switch from growing rice, which requires a much higher amount of water, to growing crops such as maize, which requires a lower amount of water. According to one estimation, crop diversification with maize enhances soil health since it does not entail the operation of puddling. This helps to prevent the deterioration of soil structure, as well as reduce water footprints and increase water productivity in a manner that is sustainable. According to the study that the Johl Committee put up and presented in the year 2002, at least one million hectares of land must be replanted to grow crops that use less water.

Conclusion

In the region, a variety of resource conservation technologies are being developed, tested, and therefore suggested in order to reduce the water, carbon, and energy footprints, notably in the rice-wheat cropping sequence. However, these RCTs later proved to be site- and context-specific, and thus are not universally applicable. In addition, only short-duration rice varieties and timely rice seedling transplantation appear to be true water-saving technologies among all RCTs. This is because they prevent cutting off drainage loss, which is essential in water-constrained locations. However, all of the other RCTs that were supposed to stop drainage losses stated that they were only effective in waterlogged places. These RCTs are better known as "energy-saving technologies," and they had to be utilized in order to remove water from deeper underground depths. Direct seeding or mechanical transplanting in rice under zero-tilled plots and minimum or zero tillage with full straw loads in wheat are essential interventions. These interventions shared mulching benefits and partitioned the highest share of evaporation to transpiration, which cut down water and energy footprints, and improved grain yields with higher input use efficiencies.

References

Brar, A. S., Mahal, S. S., Buttar, G. S and Deol, J. S. (2011). Water productivity, economics and energetics of basmati rice (Oryza sativa)-wheat (Triticum aestivum) under different methods of crop establishment. *Indian Journal of Agronomy*. 56(4): 317-320.

Kukal, S. S., Singh, Y., Yadav, S., Humphreys, E., Kaur, A and Thaman, S. (2008). Why grain yield of transplanted rice on permanent raised beds declines with time? *Soil and Tillage Research*. 99(2): 261-267.

Nthebere, K., Prakash, T. R., Jayasree, G., Padmaja, B., Meena, A and Latha, P. C. (2023). Changes in Soil Physical Properties and Available Micronutrients as Influenced by Tillage and Weed Management Strategies under Diversified Cropping System. *Biological forum-An international Journal*. 15(9): 131-140.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

HUMIC ACID-BOOSTING NUTRIENT TRANSFORMATION AND CROP PRODUCTIVITY

Article ID: AG-V04-I12-71

***Annappa, N. N[1] and Krishna Murthy, R[2]**

[1]Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, UAS, Bangalore-65

[2]Professor and Scheme Head, AICRP on STCR, Department of Soil Science and Agricultural Chemistry, UAS, Bangalore-65, Karanataka, India

: *Corresponding Author Email ID: annappann61@gmail.com

Abstract

Humic acid, a natural substance from decomposed organic matter, plays a vital role in sustainable agriculture by enhancing nutrient transformation, soil fertility, and crop productivity. It improves nutrient solubility, cation exchange capacity, and microbial activity, ensuring better nutrient availability and uptake. With chelating properties, it prevents micronutrient deficiencies and supports robust root growth and photosynthesis, boosting yields and plant resilience to stress. Used in soil amendments, foliar sprays, and integrated with NPK fertilizers, humic acid reduces dependency on chemical inputs and enhances soil organic carbon. Despite challenges like inconsistent quality, its integration into precision farming holds promise for sustainable agricultural advancement.

Keywords: Humic acid, nutrient transformation, soil fertility, crop productivity, sustainable agriculture.

Introduction

In the journey toward sustainable and productive agriculture, humic acid has gained recognition as a natural soil amendment with transformative potential. Derived from the decomposition of organic matter, humic acid plays a pivotal role in enhancing nutrient transformation, improving soil fertility, and ultimately boosting crop productivity. Its versatility and eco-friendly nature make it an essential component of modern agricultural practices.

What is Humic Acid?

Humic acid is a complex organic substance formed during the decomposition of plant and animal residues. It is a key component of humus and is known for its ability to interact with soil minerals, nutrients, and water (**Vikram *et al*., 2022**). Available in liquid, granular, and powdered forms, humic acid is widely used to improve soil structure, nutrient availability, and plant growth.

How Does Humic Acid Influence Nutrient Transformation?

Humic acid plays a crucial role in nutrient transformation by improving the availability and efficiency of essential nutrients in the soil. It enhances the solubility of key nutrients like nitrogen, phosphorus, and micronutrients, making them more accessible for plant uptake. By increasing the soil's cation exchange capacity (CEC), humic acid improves the soil's ability to retain and exchange nutrients, preventing losses through leaching and ensuring a consistent supply to plants (**Ampong *et al*., 2022**). Additionally, humic acid stimulates the activity of beneficial soil microbes, which are vital for nutrient cycling and the conversion of organic and inorganic compounds into forms that plants can readily absorb. Furthermore, its chelating properties stabilize trace elements such as iron, zinc, and manganese, ensuring their availability in the soil and minimizing nutrient deficiencies in crops. Together, these mechanisms highlight humic acid's significant contribution to nutrient transformation and soil fertility.

Benefits for Crop Productivity

Humic acid significantly enhances crop productivity through various mechanisms that improve plant growth and resilience. It stimulates root elongation and branching, enabling plants to absorb water and nutrients more effectively from the soil. This robust root system supports overall plant health and development. By facilitating better nutrient uptake, humic acid boosts chlorophyll synthesis, which enhances photosynthetic efficiency and contributes to vigorous plant growth. The improved nutrient availability and utilization result in higher crop yields and superior produce quality. Additionally, humic acid strengthens plants' ability to withstand environmental stressors such as drought, salinity, and temperature fluctuations, making it an invaluable tool for maintaining productivity under challenging conditions (**Khan *et al*., 2024**).

Mechanisms of Action

- **pH Buffering**: Stabilizes soil pH, optimizing conditions for nutrient uptake.

- **Ionic Transport**: Facilitates the movement of nutrients through the plant cell membranes.
- **Detoxification**: Binds toxic heavy metals, reducing their harmful effects on plants.

Applications in Agriculture

1. **Soil Amendment**
   - Application through compost, biochar, or humic acid-enriched fertilizers.
   - Benefits in saline and sodic soils by reducing sodium toxicity.
2. **Foliar Sprays and Seed Treatments**
   - Direct uptake by plants through leaves or seeds, providing immediate growth benefits.
3. **Integration with Fertilizers**
   - Use of humic acid in combination with NPK fertilizers improves nutrient efficiency.

Environmental and Economic Benefits

- Reduces dependency on chemical fertilizers by improving nutrient uptake efficiency.
- Enhances soil organic carbon, contributing to long-term soil health.
- Cost-effective for farmers due to reduced input costs and increased yield.

Challenges and Future Directions

While humic acid offers remarkable benefits, challenges like inconsistent product quality and lack of awareness among farmers limit its widespread adoption. Research is underway to standardize humic acid formulations and optimize application methods. Increased integration of humic acid into precision farming practices holds promise for enhancing its efficacy and impact.

Conclusion

Humic acid serves as a bridge between soil health and crop productivity. Its ability to transform nutrients and improve plant growth while being environmentally friendly makes it a cornerstone of sustainable agriculture. By incorporating humic acid into farming systems, we can achieve higher yields, healthier soils, and a greener future.

References

Vikram, N., Sagar, A., Gangwar, C., Husain, R. and Kewat, R.N., 2022. Properties of humic acid substances and their effect in soil quality and plant health. In *Humus and humic substances-recent advances*. IntechOpen.

Ampong, K., Thilakaranthna, M.S. and Gorim, L.Y., 2022. Understanding the role of humic acids on crop performance and soil health. *Frontiers in Agronomy*, *4*, p.848621.

Khan, N.M., Mujtaba, G., Irfan, M.A., Ahmed, M., Kebe, A.A., Ahmed, R. and Fayaz, F., 2024. Salicylic Acid with Humic Acid Addition as Potential Hallmarks for Alleviating Drought Stress in Maize Crop and Enhancing Soil Health. *Asian Research Journal of Agriculture*, *17*(1), pp.10-21.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

ARSENIC IN SEAFOOD: SOURCE, SPECIATION, HEALTH EFFECTS AND MITIGATION MEASURES

Article ID: AG-VO4-I12-72

***Rajendran Shalini[1], Ulaganathan Arisekar[1], Balasubramanian Sivaraman[1] and Shanmugam Sundhar[1]**

[1]Department of Fish Quality Assurance and Management

Fisheries College and Research Institute

Tamil Nadu Dr. J. Jayalalithaa Fisheries University

Thoothukudi-628 008, Tamil Nadu, India

*Corresponding Author Email ID: shalini@tnfu.ac.in

Abstract

Arsenic is a naturally occurring metalloid widely found in the environment, including seafood, which is a significant dietary source of arsenic for humans. This review examines the sources, speciation, health effects, and mitigation measures related to arsenic in seafood. Arsenic in seafood predominantly exists in organic forms, such as arsenobetaine and arsenosugars, which are considered less toxic compared to inorganic arsenic species like arsenite and arsenate. The bioaccumulation of arsenic in seafood is influenced by environmental factors, including contamination from natural geological processes, anthropogenic activities, and aquaculture practices. Chronic exposure to inorganic arsenic, even at low levels, poses significant health risks, including carcinogenicity, cardiovascular diseases, neurotoxicity, and developmental effects. Current mitigation strategies include improved regulatory frameworks, monitoring programs, and consumer education on dietary exposure. Furthermore, technological advancements, such as enhanced seafood processing methods and the development of arsenic removal technologies, hold promise in reducing arsenic levels in seafood. This comprehensive review highlights the need for integrated approaches to minimize the health risks associated with arsenic exposure from seafood while ensuring food safety and sustainability.

Introduction

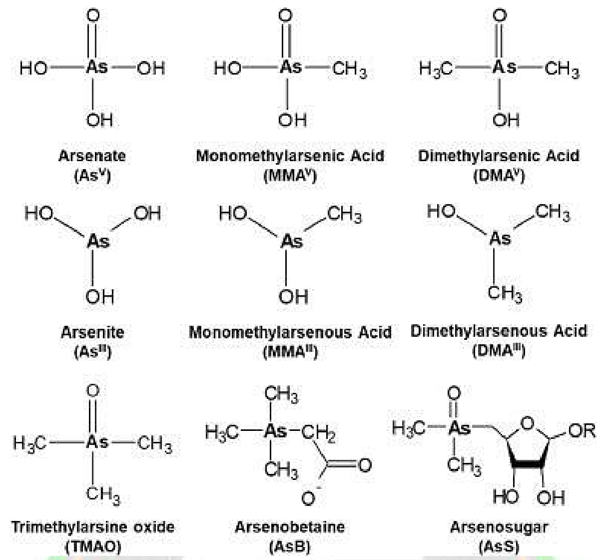
Arsenic (As) is found naturally in the earth's crust worldwide. The word "arsenic" is from the Persian word "Zarnikh", which means yellow orpiment. It was first isolated as an element by Albert Magnus in 1250. Arsenic exists in powdery amorphous and crystalline forms in the ores (Gautham et al., 2014). Arsenic is released through mineral processing and fossil fuel combustion. Arsenic is also mobilized naturally through volcanic, geothermal, and microbiological processes, and by weathering of crustal rocks. Arsenic can attach to very small particles in the air, stay in the air for many days, and travel long distances. Many common arsenic compounds can dissolve in water; thus, arsenic can contaminate lakes, rivers, or underground water by dissolving in rain, snow, or discarded industrial wastes. Arsenic is used in the manufacture of glass metal alloys, medicines, and microelectronics. It is also used as an agricultural pesticide and wood preservative as it has germicidal power and resistance to rotting and decay. Arsenic exists in inorganic and organic forms. Inorganic arsenic is divided into two types: trivalent and pentavalent arsenic. The most common oxidation states for As are 5 as arsenates and 3 as arsenites. In water, arsenic is usually found in the form of arsenate or arsenite. The most important commercial compound, arsenic III oxide, is produced as a by-product in the smelting of copper and lead ores.

Arsenic Contamination in Aquatic Environments

Concentrations of As in open seawater are less than 2 μg/L (Ng 2005), and in freshwater, 0.15–0.45 μg /L (Bissen and Frimmel 2003). High concentrations in surface water and groundwater of up to 100–5000 μg /L are found in areas of sulfide mineralization and mining (Smedley et al. 1996). Inorganic As is found in the groundwater which is used as drinking water in several parts of the world (Ahmed et al., 2011) and this water is also used for shrimp and fish culture in some places. Arsenic is bio-accumulated in aquatic organisms (Ling et al., 2005), and the use of high arsenic concentrated of groundwater for aquaculture has resulted in an accumulation of arsenic in cultured animals, such as fish and shrimp. Huang et al., (2003) and Lin et al. (2004) have reported high concentrations (>329 $\mu g\ g^{-1}$) of total arsenic in cultured fish from the arsenic-contaminated area.

Forms of Arsenic in fish

Arsenic is found in both freshwater and marine environments, but the levels of arsenic present in seawater and marine organisms are higher than in freshwater and freshwater organisms. This is because of the transformation of iAs to organic As compounds at the base of the marine food web, and the higher accumulation and retention of these organic compounds in marine organisms (Francesconi and Edmonds, 1997; Reimer et al., 2010).



Seafood is reported to be the major source of arsenic (As) (WHO-IARC, 2011), with concentrations in many fish and shellfish exceeding most of the terrestrial foods. In the marine food the highest total Arsenic concentration was reported in seaweed (EFSA, 2009). Shellfish was found to contain higher As concentration than finfish (Lorenzana et al., 2009), and demersal fish has more As concentration than pelagic fish (Uneyama et al., 2007; Slejkovec et al., 2014; Wu et al., 2014).

Types and Distribution of Arsenic in Marine Environments and Seafood

More than 100 naturally occurring arsenic compounds have been identified in the marine environment. Arsenic compounds found in seafood are divided based on their structure and properties (Taylor et al., 2012). Arsenobetaine is the major As species in most finfish and shellfish and in zooplankton (Shibata et al., 1996; Takeuchi et al., 2005). Arsenosugars are high in marine algae, (Feldmann and Krupp, 2011), molluscs (Whaley-Martin et al., 2012), and crustaceans (Terol et al., 2012). Arsenolipids include fatty acids (AsFA), hydrocarbons (AsHC), glycol phospholipids (AsPL), As-containing alcohols, phosphatidylcholines, and phosphatidylethanolamines (Taylor et al., 2017). These compounds are associated with fatty fish and fish oils. The brown algae, hijiki (*Sargassum fusiformes*), an edible seaweed is reported to contain high amounts of total As, the majority of which is in inorganic form (Hirata and Toshimitsu, 2007, Rose et al., 2007). Maulvault et al. (2015) reported high proportions of iAs, in some other species of brown algae. Koch et al. (2007) reported high concentrations of arsenic (230 mg/kg) in clam tissue with unusually high proportions of inorganic arsenic (> 40%).

Factors Influencing Arsenic Speciation and Accumulation in Marine Organisms

The As concentration in sediments and water, the proximity to a point source of contamination and organisms' feeding mechanism affect the concentration of inorganic arsenic (Lorenzana et al., 2009; Whaley-Martin et al., 2012) whereas, levels of organic As in fish and shellfish are not affected by contaminated sites (Whaley-Martin et al., 2012). Pelagic fish have a lesser proportion of iAs (Julshamn et al., 2012), whereas benthic fish and shellfish can accumulate high concentrations of iAs (Lorenzana et al., 2009). Methylated As compounds are formed by enzymatic methylation of iAs to compounds containing 1–4 methyl groups. These compounds generally occur as minor As species in seafood, in which DMA is the most prominent. The proportion of DMA is higher in molluscs (3–46%) than in finfish or algae (Whaley-Martin et al., 2012; Berges-Tiznado et al., 2013), whereas monomethyl As (MA) is generally present in trace amounts. The trimethylated form occurs in higher concentrations in some fish species. Edmonds et al. (1997) reported that the predominant form of arsenic in marine animals as arseno betaine, a tri-methylated pentavalent (As[V]) compound. The proportion of inorganic arsenic in fish is as low as 1-4% of total arsenic (National Research Council, 1999). Peshut et al. (2008) reported inorganic arsenic content of less than 0.5% in marine fish and shellfish from American Samoa except few samples of mollusk which contained 1-5%.

Toxicity, Health Effects, and Exposure Risks of Arsenic

The toxic effects of arsenic depend on oxidation state, chemical species, exposure and dose, solubility in the biological media, and rate of excretion (Peshut et al., 2007). Inorganic arsenic [sum of arsenite As (III) and arsenate As (V)] is highly toxic. The arsenite and arsenate forms have different modes of action. Arsenite binds to sulfhydryl groups and inhibits over 100 different enzymes, whereas the arsenate ($HAsO_4 2-$), which is a molecular analogue of phosphate ($HPO_4 2-$), can compete for phosphate anion transporters and replace phosphate in some biochemical reactions. In addition, when arsenate is reduced to arsenite in the body, it can also cause toxicity. The simple methylated arsenic compounds show intermediate toxicity and the trimethylated arsenic compounds, arsenobetaine, are nontoxic.

Inorganic arsenic is recognized as a class 1 human carcinogen (IARC, 1987), and human exposure to inorganic arsenic should be as low as possible. Long-term exposure to inorganic arsenic includes pigmentation changes, skin lesions and hard patches on the palms and soles of the feet (hyperkeratosis), diabetes, pulmonary disease, cardiovascular disease, and arsenic-induced myocardial infarction (WHO, 2020). Arsenic is also associated with adverse pregnancy outcomes and infant mortality, with impacts on child health (Quansah et al., 2015). The daily intake rates for inorganic As in different parts of the world have been reported as 4.8 µg/day (Canada- Yost et al., (1998), 5.6 µg/day (UK- TOX/2002), 5.8 µg/day (Belgium- Baeyens et al., 2009), 8.3 µg/day (US, Yost et al., 1998) and 56 µg/day (Bangladesh- Kile et al., 2007).

Impact of Cooking Methods on Arsenic Concentration in Seafood

Cooking affects arsenic concentration and changes in arsenic speciation. Many researchers reported that cooking, washing, and adding spices causes the transformation of As species (Devesa et al., 2001; Devesa et al., 2008; Perello et al., 2008; Schmidt et al., 2017). Ling et al. (2014) studied the changes in arsenic concentration upon different cooking methods and reported that frying resulted in the highest increase in As concentration followed by grilling and baking Xu et al. (2020) studied the effects of steaming on the As distribution in different tissues of scallop and reported that steaming lead to the redistribution of As in various parts with the migration of moisture, and highest amount of As emigration was observed in the viscera. They further reported that after 15 min of steaming, more than 29% of As was transferred from the scallop soft tissues to the juice, which meant the soups cooked with whole scallops had a safety risk on consumption. Van Elteren and Slejkovec (1997) reported that a temperature above 150^0C was required to transform arsenic species.

Conclusion

Arsenic contamination in seafood is a significant concern due to its potential health effects on humans. The sources of arsenic in marine environments are both natural and anthropogenic, with its speciation playing a crucial role in determining its toxicity. While organic arsenic compounds like arsenobetaine are relatively non-toxic, inorganic arsenic forms are highly toxic and pose serious health risks, including carcinogenicity and other chronic health conditions. The cooking and processing of seafood influence arsenic concentrations and speciation, often altering the risk profile of the consumed product. Studies reveal that certain cooking methods, such as frying and steaming, can increase arsenic concentrations or lead to redistribution across tissues, emphasizing the need for awareness about safe preparation practices. Mitigation measures, including monitoring arsenic levels in aquaculture systems, proper management of contaminated waters, and public awareness about arsenic-safe cooking and consumption practices, are crucial to reducing health risks. Continued research on arsenic dynamics in seafood and human health impacts is essential for informing regulations and ensuring food safety worldwide.

References

Devesa, V., Vélez, D. and Montoro, R., 2008. Effect of thermal treatments on arsenic species contents in food. *Food and Chemical Toxicology*, *46*(1), pp.1-8.

Kile, M.L., Houseman, E.A., Breton, C.V., Smith, T., Quamruzzaman, Q., Rahman, M., Mahiuddin, G. and Christiani, D.C., 2007. Dietary arsenic exposure in Bangladesh. *Environmental health perspectives*, *115*(6), pp.889-893.

Taylor, M.P., Mould, S.A., Kristensen, L.J. and Rouillon, M., 2014. Environmental arsenic, cadmium and lead dust emissions from metal mine operations: Implications for environmental management, monitoring and human health. *Environmental research*, *135*, pp.296-303.

Yost, L.J., Schoof, R.A. and Aucoin, R., 1998. Intake of inorganic arsenic in the North American diet. *Human and Ecological Risk Assessment: An International Journal*, *4*(1), pp.137-152.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

TECHNOLOGICAL BREAKTHROUGHS IN AGRICULTURAL SPRAY APPLICATION

Article ID: AG-VO4-I12-73

***Satyam Singh**

M. Tech. (FMPE) Scholar, ANDUAT, Kumarganj U. P. India

*Corresponding Author Email ID: satyamsingh74089@gmail.com

Introduction

Agriculture has evolved significantly over the centuries, with technological advancements driving the way crops are cultivated, managed, and harvested. Among the many tools that have revolutionized modern farming, sprayers stand out as one of the most important. These devices, used for the application of pesticides, herbicides, fungicides, and fertilizers, play a vital role in maintaining crop health, boosting yields, and ensuring food security across the globe. Today, the use of sprayers is an essential component of sustainable agriculture, allowing farmers to optimize their resources, protect their crops, and improve productivity.

Agricultural technology has undergone dramatic transformations, particularly in the 20th and 21st centuries. From the invention of the plow and the combine harvester to the advent of genetically modified organisms (GMOs) and precision farming tools, innovations in technology have helped farmers to produce more food on less land, with greater efficiency and fewer resources.Sprayers are often at the forefront of discussions about sustainable farming because they allow for precision application—a practice that ensures only the necessary amounts of fertilizers and pesticides are used. By reducing the over-application of chemicals, sprayers contribute to environmental sustainability by minimizing chemical runoff, reducing waste, and protecting water sources.

Importance of Sprayers in Modern Farming

The importance of sprayers in modern agriculture cannot be overstated. From their role in pest control to their impact on crop nutrition and yield, sprayers have become essential tools for farmers worldwide. Below, we highlight several key reasons why sprayers are integral to contemporary farming practices.

A. Pest and Disease Management

Pest and disease management are critical aspects of modern agriculture, as pests and diseases can cause significant crop losses. Sprayers allow farmers to apply pesticides and fungicides quickly and effectively, minimizing damage from pests, insects, and pathogens. The ability to apply treatments uniformly across large fields ensures that crops are protected, leading to healthier plants and higher yields.

B. Fertilization and Nutrient Management

In addition to pest control, sprayers are used to apply liquid fertilizers to crops. Fertilization is essential for plant growth, as crops need specific nutrients such as nitrogen, phosphorus, and potassium to thrive. Sprayers enable farmers to deliver these nutrients directly to the plants, often in the form of foliar feeding, which allows for quicker absorption than traditional soil-based fertilization.

C. Time and Labor Efficiency

Sprayers help farmers save time and labor by automating the process of chemical application. Instead of manually spraying crops, which is time-consuming and labor-intensive, modern sprayers can cover vast areas quickly and efficiently. This increases productivity and reduces the number of laborers needed, making it particularly important in large-scale farming operations.

D. Increased Yield and Quality

By ensuring that crops are protected from pests and diseases, and by providing essential nutrients, sprayers contribute to increased crop yields and improved quality. A healthy, well-nourished crop is more likely to grow vigorously, resulting in higher harvests. Sprayers also enable timely application, which is crucial for preventing yield losses due to delayed pest control or fertilization.

E. Environmental Sustainability

As the agricultural industry faces growing pressures to reduce its environmental footprint, sprayers offer a solution through precision application. Modern sprayers minimize chemical waste by applying only the necessary amount of pesticide, herbicide, or fertilizer, reducing the risk of runoff into nearby water sources. Furthermore, sprayers equipped with technologies such as drift reduction and targeted application contribute to more environmentally sustainable farming practices.

F. Adaptability Across Crop Types and Farming Systems

Sprayers are highly versatile and can be adapted to suit a variety of crops and farming systems. Whether for row crops like wheat and corn, orchards, vineyards, or even greenhouse crops, sprayers are tailored to deliver precise coverage in different environments. Additionally, sprayers can be adjusted to handle different types of chemicals and fertilizers, making them suitable for various agricultural practices.

Evolution of Sprayers: From Manual to Automated

The history of sprayers stretches back to the early days of agriculture, when farmers would apply chemicals by hand or with basic mechanical devices. Early sprayers included simple handheld sprayers and pump-action sprayers, which were labor-intensive and inefficient. These tools were sufficient for small-scale or subsistence farming, but as agriculture grew and mechanized, there was a need for more efficient and effective sprayer technology.

Early Sprayers and Boom Sprayers

The first significant advancement in sprayer technology was the development of boom sprayers in the early 20th century. These sprayers allowed for faster, more consistent coverage of large fields. The boom sprayer, mounted on tractors or self-propelled vehicles, could cover a wide area at once with a series of nozzles that sprayed a uniform layer of chemicals or fertilizers. This innovation greatly improved efficiency and allowed farmers to manage larger tracts of land.

Precision Sprayers and the Rise of GPS Technology

As the agricultural industry grew and faced increasing challenges—such as the need for higher productivity, cost-efficiency, and environmental sustainability—sprayers evolved into more sophisticated machines. In the late 20th and early 21st centuries, precision agriculture took off, introducing tools that enable farmers to apply inputs with incredible accuracy and reduce the overuse of chemicals.The integration of GPS technology into sprayers was one of the most significant advancements in this field. GPS guidance systems enable sprayers to follow specific paths across a field, ensuring precise coverage and minimizing overlap. This technology allows farmers to automate much of the spraying process, resulting in higher efficiency and less wasted input.

Automation and Data-Driven Sprayers

Automation has become the next frontier in sprayer technology. Modern sprayers can be equipped with sensors, cameras, and AI-driven algorithms to automatically adjust the application rate, track field conditions, and provide real-time data on the application process. Automated sprayers are capable of adjusting the amount of pesticide or fertilizer applied in real-time, based on changing conditions in the field, such as varying levels of weed or pest infestations.

4.2 Smart Spraying: GPS and Sensor-Driven Sprayers

The integration of smart technology into sprayers has had a transformative impact on agriculture. By using GPS, remote sensing, and data analytics, modern sprayers can operate with unprecedented precision. This chapter focuses on some of the most important technologies that have made sprayers smarter and more efficient.

A. GPS-Guided Sprayers

GPS technology has revolutionized the way sprayers are used in agriculture. GPS-guided sprayers are able to map out precise routes across a field, ensuring that every part of the field receives the right amount of treatment, with minimal overlap or gaps. Key features of GPS-guided sprayers include:

- **Auto-steering**: With auto-steering systems, sprayers can move across a field with pinpoint accuracy, following a pre-determined path without manual guidance.
- **Section control**: Section control is a feature of GPS-guided sprayers that allows the sprayer to automatically turn off certain sections when they pass over areas that have already been sprayed, avoiding over-application of chemicals and reducing waste.
- **Field mapping**: Sprayers can map out specific parts of a field that need more attention, such as areas with higher pest or weed pressure, and adjust application rates accordingly.

With GPS, sprayers can efficiently cover vast areas without missing any spots, improving both the speed and accuracy of spraying operations. GPS-guided systems also allow farmers to better track and document spraying activities, providing valuable data for record-keeping and compliance with environmental regulations.

B. Sensor-Driven Sprayers

In addition to GPS, sprayers are increasingly using sensors to adjust applications based on real-time conditions. There are several types of sensors integrated into modern sprayers, including:

- **Optical sensors**: These sensors detect variations in crop health and pest activity by scanning the plants and soil below. For example, optical sensors can detect areas of a field that are infested with weeds, and the sprayer will only apply herbicide to those specific areas.
- **NIR (Near-Infrared) sensors**: These sensors can measure the **chlorophyll levels** in plants, helping to identify areas that need nutrients or treatment for fungal diseases.
- **Radar and ultrasonic sensors**: These sensors measure the distance to the target and help sprayers maintain the correct height above the crop for even application. This ensures that the sprayer operates optimally, avoiding drift and over-spraying.

By using sensors, sprayers can automatically adjust the flow rate of pesticides, fertilizers, or fungicides, ensuring that only the necessary amount is applied to the correct areas. This makes spraying operations more efficient and reduces the environmental impact of over-application.

C. Variable Rate Application (VRA)

Variable rate application (VRA) is a technique in which the amount of pesticide, fertilizer, or herbicide applied to a field is adjusted based on specific needs. VRA uses data collected from sensors, GPS systems, and field mapping to determine where and how much input is needed in different areas of the field. For example:

- In fields where pest pressure is low, VRA can reduce the amount of pesticide applied, saving both resources and money.
- Similarly, in areas of a field that need more nutrients, VRA allows for targeted fertilization, preventing the waste of expensive fertilizers.

By applying the precise amount of chemicals or fertilizers required, VRA technology minimizes input costs and reduces environmental pollution. It also allows farmers to improve crop yields by addressing variations in soil fertility or pest populations.

Drones and Aerial Sprayers

As agriculture becomes more data-driven and automated, drones have emerged as a game-changing technology in the spraying industry. Drone sprayers are revolutionizing the way chemicals and fertilizers are applied, particularly in difficult-to-reach areas like orchards, vineyards, and steep terrain. This section explores the role of drones and aerial sprayers in modern farming.

A. Drone Sprayers

Drone technology, particularly unmanned aerial vehicles (UAVs), has taken the sprayer industry to new heights—literally. Drones are now being used to apply pesticides, fungicides, and fertilizers with incredible precision. The key advantages of drone sprayers include:

- **Access to difficult terrain**: Drones can fly over areas that may be difficult or dangerous for traditional sprayers to reach, such as mountain slopes or densely planted crops like vineyards.
- **Precision application**: With built-in sensors and GPS systems, drones can apply chemicals to targeted areas with minimal waste or over-application.
- **Speed and cost-efficiency**: Drones can cover large areas quickly, often at a fraction of the cost of using manned aircraft or ground-based sprayers.

Drones can carry small payloads of liquid or granular chemicals and are able to spray over the crops using a controlled and consistent spray pattern. They are especially useful in precision agriculture, where the ability to precisely apply inputs can result in significant cost savings and increased yields.

B. Aerial Sprayers (Fixed-Wing Aircraft and Helicopters)

While drones are ideal for smaller fields or areas that require detailed, targeted application, manned aircraft such as fixed-wing planes and helicopters are still used for large-scale aerial spraying. Aerial spraying is often employed for broadacre crops like wheat, corn, or rice, or in large plantations like oil palm. Some benefits of aerial spraying include:

- **Speed**: Aircraft can cover large fields in a short amount of time, which is crucial for time-sensitive applications, such as during pest outbreaks or before a rainstorm.
- **Large-scale coverage**: For crops planted on thousands of acres, aerial spraying offers the ability to apply treatments over vast areas efficiently.

Despite the higher costs associated with aerial sprayers, they remain an essential tool for large-scale agricultural operations, particularly when ground-based equipment is impractical or inefficient.

The Future of Sprayer Technology

The future of sprayer technology is bright, with innovations focused on improving efficiency, sustainability, and automation. Some potential future trends include:

- **Fully autonomous sprayers**: Sprayers that can operate without human intervention, using advanced sensors, GPS, and AI to make real-time decisions about pesticide and fertilizer applications.

- **AI-driven optimization**: Sprayers may soon be able to analyse data from sensors and other sources, predicting pest and disease outbreaks before they occur and automatically adjusting application rates.
- **Sustainability**: The development of more environmentally friendly sprayers, including those that reduce chemical drift, minimize runoff, and use eco-friendly formulations, will continue to gain momentum.
- **Integration with farm management software**: Sprayers will become even more connected to farm management systems, allowing farmers to monitor and control their operations remotely and in

Volume: 04 Issue No: 12

ENDOPHYTIC MICROBIOME SEED COATING TECHNOLOGY: A GAME-CHANGER AGAINST SEED-BORNE PATHOGEN, *COLLETOTRICHUM CAPSICI* (ANTHRACNOSE FRUIT ROT) IN CHILLI

Article ID: AG-VO4-I12-74

[*1]Kambam Harika, [2]Dr. P. Sujatha,[3]Dr. P. Jagan Mohan Rao, [4]Dr. G.Padmaja, [5]Dr. K. Damodar Chari, [6]Dr. SNCVL Pushpavalli

[1]PhD Research scholar, Department of Seed Science and Technology, Professor Jayshankar Telangana Agriculture University, Rajendranagar-500030.

[2]Associate Professor, Department of Seed Science &Technology, SRTC, PJTSAU, Rajendranagar, Hyd-500030.

[3]Director(Seeds) & Univ. Head, Department of Seed Science &Technology, SRTC, PJTSAU, Rajendranagar, Hyd-500030.

[4]Scientist, Plant Pathology, AICRP on kharif Pulses RARS, Warangal.

[5]Assistant Scientific Officer (Microbiology), Agriculture Technology Information Center, NIPHM, Rajendranagar, Rangaredy, Telangana.

[6]Assistant Professor, Molecular Biology & Biotechnology, Institute of Biotechnology, PJTSAU, Hyderabad-30.

*Corresponding Author Email ID: harikakambam98@gmail.com

Introduction

Chilli (*Capsicum annuum* L.), often referred to as the "King of Spices," is an integral component of global cuisine, known for its pungent flavor, vibrant color, and nutritional benefits. Beyond its culinary significance, chilli also holds substantial economic value, being a major cash crop in many countries, including India. However, the successful cultivation of chilli is frequently challenged by a range of diseases, with anthracnose, caused by the fungal pathogen *Colletotrichum capsici*, standing out as one of the most devastating.

Anthracnose manifests as dark, sunken lesions on the fruits, stems, and leaves of chilli plants, leading to significant yield losses and reduced marketability of the produce. The pathogen's ability to thrive under a wide range of environmental conditions, various modes of inoculum transmission, and its capacity to infect the host plant at various growth stages make it a challenging adversary for chilli farmers. Traditional methods to combat *Colletotrichum capsici* include the use of chemical fungicides, but these are increasingly scrutinized due to their environmental impact, the potential development of fungicide resistance, and concerns over food safety. In response to these challenges, the agricultural sector is witnessing a paradigm shift towards more sustainable and environment friendly solutions. One such innovative approach is the integration of seed coating technology with endophytic microbiomes. This method not only aims to protect the chilli seeds and seedlings from pathogens but also enhances the overall health and resilience of the plants through the use of beneficial microorganisms.

The combination of seed coating technology with endophytic microbiomes represents a cutting-edge strategy in crop protection. By incorporating beneficial endophytes into the seed coating, it is possible to create a microenvironment around the seed that is hostile to pathogens like *Colletotrichum capsici*, while simultaneously fostering a supportive environment for the seedling development. This dual action—protection and promotion—makes this approach particularly attractive in the context of sustainable agriculture. However, the successful implementation of this technology requires careful standardization. The choice of endophytic strains, the formulation of the coating mixture, the application techniques, and the conditions under which the coated seeds are stored and planted all need to be optimized to achieve consistent and effective results. This standardization process is essential to ensure that the benefits of the technology can be reliably reproduced across different regions and farming practices.

In this context, the study of seed coating technology with endophytic microbiomes against *Colletotrichum capsici* in chilli is not just an academic exercise, but a practical necessity. It offers a potential solution to a pressing problem faced by chilli farmers worldwide. By reducing reliance on chemical fungicides and harnessing the natural protective mechanisms of endophytic microbiomes, this approach aligns with the broader goals of sustainable agriculture—ensuring high yields, protecting the environment, and promoting the health of both plants and consumers.

This article explores the intricacies of standardizing seed coating technology with endophytic microbiomes, focusing on its application against *Colletotrichum capsici* in chilli.

It delves into the principles behind this technology, the process of standardization, and the potential benefits and challenges associated with its adoption. Through this exploration, the article aims to shed light on a promising innovation that could play a crucial role in securing the future of chilli cultivation in an increasingly challenging agricultural landscape.

What is Seed Coating Technology?

Seed coating technology involves applying a protective layer of materials and active ingredients around seeds. This coating serves multiple purposes: it protects seeds from environmental stress, enhances seedling growth, and incorporates various biological and chemical agents to combat pathogens. Standardizing this technology is crucial to ensure consistent and effective outcomes across different environmental conditions and farming practices.

The Role of Endophytic Microbiomes

Endophytic microbiomes are communities of microorganisms that live within plant tissues without causing harm. They offer several benefits, including enhanced nutrient uptake, growth promotion, and disease resistance. Endophytes can outcompete or inhibit the growth of *Colletotrichum capsici*, providing an organic and sustainable method to protect crops.

Recent research has demonstrated that endophytic fungi and bacteria can significantly improve plant health by:

1. **Producing Antifungal Compounds**: Certain endophytes produce substances like Alkaloids, Terpenes, Phenolic compounds, Volatile organic compounds (VOCs), Chitinase that inhibit the growth of pathogens.
2. **Inducing Systemic Resistance**: Endophytes can trigger the plant's own defense mechanisms against diseases by triggering defence enzymes like Cell wall-degrading enzymes (β-1,3-Glucanase, Cellulase), Proteolytic enzymes (Protease, Pepstatin), Lipolytic enzymes (Lipase, Phospholipase), Amylase, Xylanase, Pectinase.
3. **Improving Soil Health**: Endophytes can enhance nutrient availability and soil structure, indirectly boosting plant resilience.

Procedure of Endophytic Microbiome Seed Coating Technology

To effectively incorporate endophytic microbiomes into seed coating technology, a standardized approach is essential. This involves:

1. **Selection of Endophytes**: Choosing the right endophytic strains is critical. For the control of *Colletotrichum capsici*, researchers focus on endophytes that exhibit strong antagonistic activity against the pathogen. This selection process involves isolating and screening various endophytes from healthy plants collected from the pathogen infected fields and assessing their efficacy in laboratory and field trials.
2. **Formulation of Coating Mixtures:** Once effective endophytes are identified, they are integrated into seed coating formulations. This mixture typically includes adjuvants (e.g., polymers, sugar / jaggery syrup, gum arabic) that ensure even distribution and adhesion of the endophytes to the seed surface. Standardizing these formulations involves optimizing the concentration of endophytes and other components to maximize effectiveness and shelf-life.
3. **Application Techniques:** The method of applying the coating materials (adjuvant and endophtes) to seeds impacts its performance. Techniques such as spraying, dipping, or rolling seeds with the coating mixture are evaluated for their efficiency. Standardized protocols ensure that seeds receive a uniform coating, which is crucial for consistent disease protection.
4. **Testing and Quality Control:** Rigorous testing is to be conducted to ensure that the seed coating performs effectively under various environmental conditions. This includes assessing the viability of endophytes after coating, their ability to colonize plant tissues, and their impact on disease reduction. Quality control measures are established to maintain the effectiveness of the coating across different batches.

Impact on *Colletotrichum capsici*

The integration of endophytic microbiomes into seed coating technology offers the following promising results in the management of *Colletotrichum capsici*.

1. Enhanced Disease Resistance: Seeds coated with endophytic microorganisms show improved resistance to anthracnose. Endophytes inhibit the pathogen’s ability to infect and colonize plants, reducing the incidence and severity of disease outbreaks.

2. Improved Plant Growth: In addition to disease resistance, endophyte-coated seeds often exhibit better germination rates and healthier seedlings. The growth-promoting effects of endophytes contribute to stronger plants that are better able to withstand environmental stress.

3.Sustainable Solution: Unlike chemical treatments, which can lead to resistance and environmental harm, endophytic-based seed coatings provide a natural, eco-friendly alternative. This approach aligns with sustainable agriculture practices by reducing the need for chemical fungicides and promoting soil health.

Future Directions

Keeping in view of the promising results of this technology, research needs to be refined and expanded for the use of endophytic microbiomes in seed coating technology. Future efforts may include:

1. **Exploring New Endophyte Strains:** Continued research to discover and test new endophytic strains with even greater efficacy against *Colletotrichum capsici* and other pathogens.
2. **Scaling Up of Production:** Developing methods to scale up production of endophyte-coated seeds to meet the needs of commercial agriculture.
3. **Long-Term Impact Studies:** Conducting long-term studies to assess the durability of the endophytic effects and their impact on soil health and overall crop productivity.

Conclusion

The standardization of seed coating technology with endophytic microbiomes represents a significant advancement in the fight against *Colletotrichum capsici* in chilli cultivation. By integrating beneficial microorganisms into seed coatings, farmers can enhance disease resistance, improve plant health, and promote sustainable agricultural practices in eco-friendly organic means. As research continues to refine and expand this technology, it holds the promise of transforming pest and disease management, contributing to more resilient and productive chilli crops.

Volume: 04 Issue No: 12

ROOT-KNOT NEMATODE IN HORTICULTURAL CROPS AND ITS MANAGEMENT

Article ID: AG-VO4-I12-75

***Poonam V. Tapre and N. K. Singh**
Department of Nematology, C. P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar, India
*Corresponding Author Email ID: taprepoonam@gmail.com

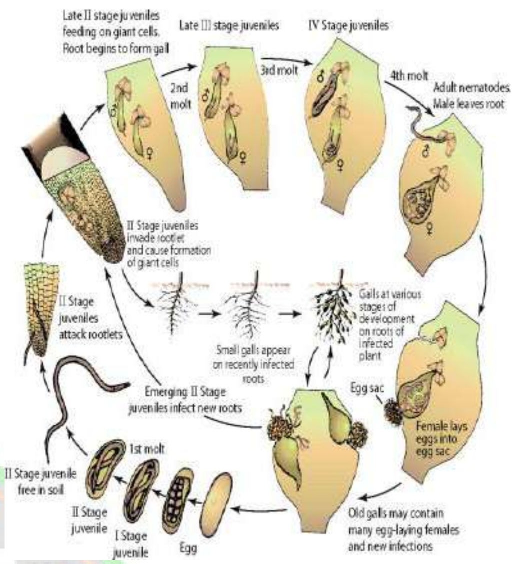
Introduction

Horticulture in India is a fast emerging as a major commercial venture, because of higher remuneration per unit area and the realization that consumption of fruits and vegetables is essential for health and nutrition. Nematodes continue threaten horticultural crops throughout the world, particularly in tropical and sub-tropical regions. For century's mans essential crop plants have been plagued by these microscopic organisms that feed on roots, buds, stems, crowns, leaves and developing seed (Reddy P., 2008). Furthermore, roots weakened and damaged by nematodes are easy to many types of fungi and bacteria which invade the roots and accelerate root decay. These deleterious effects on plant growth results in reduced yields and poor quality of horticultural crops. But the damage cause by plant parasitic nematode to agricultural and horticultural crops has been undervalued due to undiagonstic symptoms by nematodes. Fruit crops are considerably susceptible to nematode infestation and exhibit 9-28 % yield loss globally (Khan, 2008). Horticultural crops are relatively more susceptible to nematode infestation because of their soft and succulent roots and other parts, and their cultivation under conditions having greater soil moisture which greatly favor nematode infestation. The crop damage however depends on the nematode species, its population and climatic conditions. Communally occurring nematodes which attack these crops are root-knot nematode (*Meloidogyne* spp.), burrowing nematode (*Radopholus similis*), lesion nematode (*Pratylenchus* spp.), citrus nematode (*Tylenchulus semipenetrans*), spiral nematode (*Helicotylenchus* spp), reniform nematode (*Rotylenchulus reniformis*), Cyst nematode (*Globodera* spp.) *etc*.

Life cycle:

Root- knot nematode:

Root-knot nematode sedentary endoparasite and obligate in nature. The infective stage of root-knot nematode is second stage juvenile. First moulting take place within the egg and hatching gives rise to second stage juvenile. Then second stage juvenile moves between soil particles and they are attracted to plants in response to chemical stimuli emanating from susceptible roots. J2 enters into root just behind the root cap by piercing through the cell wall with the help of stylet. After penetration juvenile migrate intercellularly in cortex when juvenile finds a suitable site, it becomes immobile or sedentary.



J2 commences feeding and injects secretions from esophageal glands, several biochemical and cytological changes occur in plant near head of nematode. Then cells become enlarge to form Giant cell. These cells supply nutrition to female throughout life of nematode. J2 feeds on cell for 2-3 weeks and become flask shape and undergoes three moults and J3 and J4 formed. J3 and J4 cannot feed as they do not have stylet. After fourth moult stylet reappears and feeding starts. The feeding recommences and female become swallon shape. Thereafter, adult female lays 200-300 eggs in gelatinous matrix by the rectal glands. Duration of life cycle varies with host and environmental condition.

How serious are this nematodes and how does it spread?

These nematodes are responsible for 30 to 40% yield losses in various fruit crops. The incidence of fungal pathogen would be doubled in the presence of the nematodes. These nematodes cause breakdown of resistance to fungal diseases in this fruit crop. The nematodes spread from one area to another mainly through infected planting materials. In case of banana, paring or trimming of suckers, often done before planting is usually not sufficient to remove the infections that extend deeply into the sett.This nematode is disseminated when water that drains from infested areas gets recycled into irrigation system. Soil that adheres to implements, tyres of motor vehicles and shoes of plantation workers may also spread nematodes from one area to other area.

Where do these nematodes live?

The maximum number of nematodes is present at a distance of 25 to 50 cm from the base of the plant and at a depth of 20 to 40 cm in the soil. However, nematodes also live when crop roots get deep in the soil (Anandaraj, M., 2015).

Symptoms by RKN on different fruit crops:

Root-knot nematode (*M. inocognita*, *M. javanica*) in Pomegranate:

1. Yellowing and withering of leaves
2. Gradual wilting and drying of plant
3. Fewer and Undersized fruits
4. Often develops a wilt complex in presence of *Fusarium* spp and *Ceratocysts fimbriata*
5. Root galling often showing rotting

Root-knot nematode (*M. inocognita*, *M. javanica*) Papaya:

1. Stunted growth of plant with yellowing of leaves
2. Big soft galls on roots
3. Weak and premature dropping of fruit

Root-knot nematode (*M. enterolobii*) Guava:

1. During initial phase leaves become bronze color then plants start drying
2. Galling on root

Root-knot nematode (*M. indica*) Acid lime:

1.Yellowing of leaves starts from top to bottom and galling on roots

Root-knot infected Papaya, Guava, Acid Lime plants and roots (Source: Nematode Problems of Crops in India ICAR- AICRP on Nematodes in Agriculture)

Management Options:

1. Deep ploughing 2-3 times during summer.
2. Use resistant rootstocks /planting material which is free from nematode infection.
3. Raising healthy plants in nematode-free soil for rooting.
4. Incorporating bioagent *viz*. egg parasitic fungi *Pochonia chlamydosporia* with FYM in pits before planting.
5. Soil solarization to raise nematode-free seedling.
6. **Soil application of biopesticide:**
   - For pomegranate crop soil application of *Pochonia chlamydosporia* or *P. lilacinum* @ 100 g/plant + mustard cake@ 1.5,2.0 and 2.25kg/ha in first, second and third year respectively, two times i.e. first during November and Second during April (Walia and Chakrabarty, 2018).
   - Apply *Pochonia chlamydosporia* @ 5 kg/ha in field for papaya (Walia and Chakrabarty, 2018).
7. **Enrichment of FYM/Neem Cake/Vermicompost:**
   - One ton of well decomposed FYM has to be enriched by mixing with 2 kg each of *Pseudomonas fluorescens* + *Trichoderma harzianum* + *Paecilomyces lilacinus* formulation under shade. It has to be covered with mulch and optimum moisture of 25 - 30% has to be maintained for a period of 15 days. Once in a week thoroughly mix the FYM for maximum multiplication of and homogenous spread of the microorganisms in the entire lot of FYM.
   - Apply biopesticide enriched FYM@ three kg or enriched neem cake @ 250g or enriched vermicompost @500g/plant at time of planting and at an interval of six months (Anandaraj, M., 2015).
8. **Spraying or Drenching or application through drip irrigation system:** The IIHR patented organic formulation containing *Pseudomonas fluorescens and Trichoderma harzianum* has to be sprayed on the plants at regular intervals of 30 days at a dosage of 5g/ lit or 5ml/ lit. Organic formulation has to be given through drip/ by drenching @ 5g/ lit or 5ml/ lit. at regular interval of 30 days (Anandaraj, M., 2015).
9. **Soil application of Nematicide:** Pomegranate crop: If the incidence of root-knot nematode is high, first go for chemical nematicides for reducing the nematode

population below the damage threshold. Soil application of Fluensulfone 2% GR @ 10 g/per dripper in a pit of 5-10 cm deep below each dripper equally and give light irrigation. Maximum dose of fluensulfone should not exceed 40 g/plant or drenching with Fluopyram 34.48 % SC @ 2 ml/plant. Plants should be watered sufficiently before drenching. Fluopyrum drenching should be done @ 2 ml/plant in 1 liter of water (Sharma *et al*., 2021).

References

Sharma, J., Maity A., Mallikarjun, and Pokhare, S. Pomegranate Advisory for Feb- Mar 2021. PP: 1-6.

Anandaraj, M. (2015). Management of Nematodes in Fruit Crops. IIHR Technical Bulletin No. : 45.

Khan, M. R. (2008). Plant Nematodes- Methodology, Morphology, Systematic, Biology and Ecology, Science Publishers, New Hampshire, U. S. A. pp. 360.

Reddy, P. (2008). Diseases of Horticultural Crops: Nematode Problems and Their Management, Scientific Publisher, Jodhpur, India. pp.3

Walia, R. K. and Chakrabarti, P. K. (Eds.) 2018. Nematode Problems of Crops in India. ICAR- All India Coordinated Research Project on Nematodes in Agriculture. pp. 400.

Volume: 04 Issue No: 12

THE RELEVANCE OF POLLINIZERS IN TEMPERATE FRUIT CROPS

Article ID: AG-V04-I12-76

Suhasini Jalawadi* and Laxmipriya S V

Department of Fruit Science College of Horticulture,

Bagalkot-587 104, Karnataka, India.

*Corresponding Author Email ID: suhahort@gmail.com

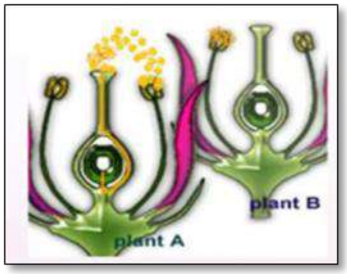
Abstract

Globally fruit crop covered an area around 68.7 million ha, where producing 867.67 million metric tones of fruit crop. Nearly 50 per cent of global volume is from temperate fruit crop. The major producing countries are china, turkey, Indonesia, Italy and spain. India is known as 2nd largest country in producing the fruit. Though, India do not fall under temperate zone. Still the high altitude of Northern east and west Himalayan range ensure temperate conditions which favours for better cultivation of temperate fruit crops. The major producing states are Jammu and Kashmir, Himachal Pradesh, Uttarkhand and some parts of eastern states Arunachal Pradesh, Assam and many more. In which, kiwi fruit among temperate fruit crop cover major area its cultivation and with respect to production, productivity Apple holds good. With the limiting area, increase in great demand. There are many factors responsible for reduction in productivity per unit area. Alternate bearing, unfriutfullness, fruit drop, abiotic and biotic stress. In which, pollination problem is major concern. Solution to overcome is accommodating adequate proportion of pollinizers in orchard results better pollination and fruit set, production.

Introduction

Pollination is the vital reproductive process which involves transfer of pollen from male reproductive organ to female reproductive organ of the same or compatible plant species. This transfer leads to the fertilization of ovules and the formation of viable seeds within the fruits (Deng *et al*., 2022).

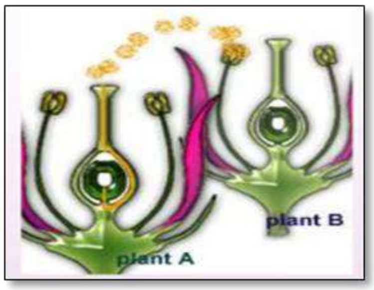
Types of pollination



Self pollination – The process of transfer of pollen grain to the stigmatic surface of same flower or different flower of same plant.

Mechanisms of Self-pollination

Cleistogamy- It is the condition where, the flowers remain closed within anther dehiscence and ensure self pollination. **e**.g. grapes and guava



Homogamy:_It is the condition where the male and female reproductive

organs mature at same time, resulting in self pollination

e.g. Some spp. of citrus, peach and apricot

Cross pollination- The process of transfer of pollen grains to the stigmatic surface of different flower of different plant or different species.

Mechanism of crosses pollination

1. Dioecy
2. Dicogamy, it is of two types
3. Protandry: male reproductive organ mature early followed by female reproductive organ
4. Protogyny: where, the female reproductive organ mature early followed by male maturity
5. Heterostyly
6. Incompatibiltiyit is the condition where the inability of pollen to germinate
7. Self-incompatibility: e.g. avocado, fig, mango, citrus, olive, aonla etc.
8. Cross-incompatibility: e.g. Loquat, plums etc.
9. Pollen sterility

All temperate fruits require pollination to set fruit. Some fruits are self-fruitful and do not require more than one cultivar per block. Peach, nectarine, tart cherry, apricot, and some European plums are self-fruitful, and a solid block of one cultivar may be planted. Apple, pear, and sweet cherries require mixed plantings of different cultivars for adequate cross-pollination.

The percentage of flowers that need to be set varies greatly between fruit crops. The more pollinizer trees in a planting, the better the potential for cross-pollination.

Five conditions are necessary for satisfactory cross-pollination:

- The availability of an adequate source of viable and compatible pollen
- The pollinating agents must effectively transfer the pollen to the stigma
- The stigma must be receptive
- There must be sufficient growth of pollen tube
- The double fertilization must take place adequately for the development of embryo and endosperm (Raja *et al*., 2018).

Factors Affecting Effective pollination

1) **Pollinizers:** Pollinizers refer to the specific plants that provide the pollen necessary for the fertilization of other plants They are the sources of pollen that are transferred by pollinators to the female reproductive organs of different plant species. In orchards, for example, certain fruit tree varieties are selected as pollinizers to provide compatible pollen for the fertilization of the desired fruit-bearing varieties.

Types of pollinizers:

a. **Interspecific Pollinizers**.
b. **Intraspecific Pollinizers**
c. **Ornamental Pollinizers**
d. **Wild Species Pollinizers**

Importance of pollinizers

- Pollinizers are crucial for facilitating cross pollination in plants that require pollen from a different individual for successful fertilization
- They help in the genetic exchange between different individuals or varieties, promoting plant adaptation and variation
- They enhance fruit yield, set and quality in the crops that rely on cross pollination
- Pollinizers contribute to genetic diversity and promote a healthy population of plants

Features of a good pollen source variety

Ø Has viable pollen that germinates well

Ø Is cross-compatible with the main variety

Ø Bloom period overlaps that of the main variety

Ø Blooms at a young age

Ø Blooms annually

Ø Is not excessively susceptible to diseases

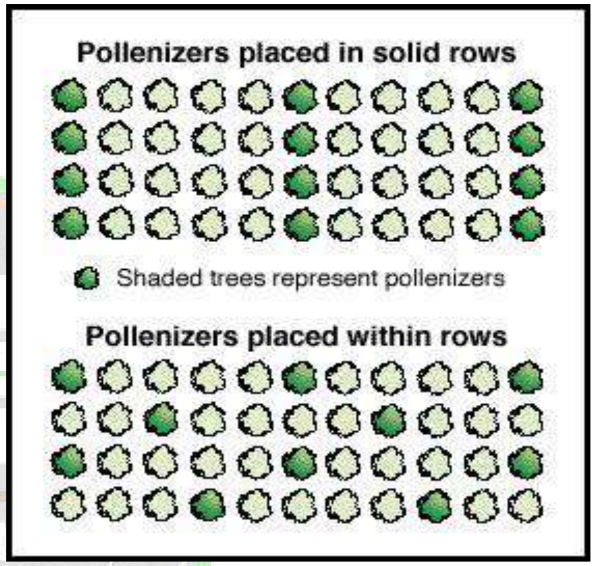
Ø Is winter hardy

Ø Produces pollen at relatively low temperatures

Ø Bear good, attractive, marketable fruits (Tatari *et al*., 2017)

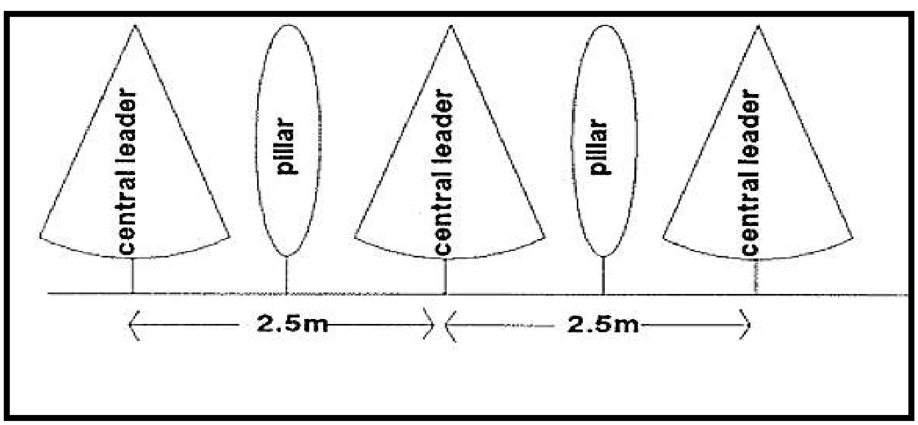
2) Pollinizer placement

The placement of Pollinizers in the orchard is very important. Ideally, every tree in an orchard should be located as close as to a Pollinizer tree. However, efficient orchard production practices do not include scattering pollinizers of commercial cultivars throughout a block. (An exception is the use of crabapples). The preferred arrangement of pollinizers is in solid rows. One scheme is to alternate two rows of Pollinizers between four rows of the major cultivar.



One scheme is to alternate two rows of pollinizers between four rows of the major cultivar. In case of HDP every 6th tree should be pollinator. Pollinizers should be planted at proper ratio i.e. 11%, 15%, 25% and 33% for effective pollination (Barzamini and Ghazvini, 2017).

1) Management of pollinizer in the orchard:



- ✓ Modern, closely spaced, high density orchards in which the trees are allowed to form solid hedge row- like canopies can cause problem for cross pollination.
- ✓ The pillar shape should be almost as tall as the main variety so that bees will fly from tree to tree throughout the foliage canopy, from pollen source to main variety etc.

Temporary aids to pollination: Used when low temperature kill or delay the bloom on pollinizer variety or weather condition reduce honey bee activity

- **Top grafting of pollen source variety**

If an orchard has not been provided with cross pollination at planting time, scions of Winter Banana or another good pollen source variety can be top grafted onto the main variety (Way, 1978). The fruits of Winter Banana has no market value and therefore will not be picked at the time of harvest. A pollen source can be quickly introduced into an orchard by top grafting than by planting new young trees. The disadvantage of this method is the necessity to clearly mark the limb to prevent it from being pruned out in the winter and mixing of fruits at the time of harvest.

- **Bouquets in the orchard**

When there is no provision made for cross pollination from another variety, open fresh blossom of an appropriate pollen source are placed in bucket of water. Fifty five gallon metal drums cut cross-section-ally through their middle make good water containers that are about 18 inches deep. Bouquets should be placed throughout the orchard; the more the better- at least one bouquet for every four trees. The use of bouquets is a poor substitute for pollinizers, and should only be considered as a temporary makeshift pollination system.

Bouquet placement

- **Use of pollen dispensers**

It is a device fitted to the hive entrance and loaded with pre-collected foreign pollen. The use of pollen dispensers increased fruit-set level and average fruit weight. However, the method is not commercialized mainly due to the high cost of imported pollen and the high risk of pathogen introduction that goes along with it. Bees exiting the hive unwillingly pick up pollen and carry it to the flowers visited (Din *et al*., 2019)

3) **Pollinators:** A pollinator is an agent (bees, flies, birds, wind or water) that moves pollen from anther to the stigma of flower which leads to the development of fruits or seeds through fertilization.

Honey bees (*Apis mellifera*) has been recognized as the primary and most effective pollinating agent.

To ensure adequate pollination of plants that are benefitted by insect pollination, colonies of honeybees should be located in or near orchards or fields at the rate of one or more strong colonies per acre

- Their body parts are modified in a way to pick up maximum possible pollen.
- Work for long hours
- Work even under adverse climatic conditions
- Large build-up of population (Warmund, 2022)

Colonies are generally placed in groups of 10 to 20 in numbers in orchards and in larger groups for the pollination of field crops (Eckert, J. E. 1960). Sharma and Gupta (2001) have reported low fruit drop and increased fruit set in orchards with increased bee colonies

Fruit crops	Number (Bee hives/ha)
Apple	3-5
Pear	3-4
Peach, Nectarine and plum	2-3
Almond	2-3
Cheery	5-8

Challenges facing pollinators and pollinizers

a. Habitat Loss
b. Pesticide Use
c. Climate Change
d. Disease and Parasites
e. Invasive Species

List of pollinizers for respective temperate fruit crops

Fruit crops	Pollinizers
Apple	Tydeman's Early Worcestor, Summer Queen, Sparten, McIntosh, Lord Lambourne, **Golden Delicious, Golden Spur, Granny Smith**, Empire, Gala
Plum	Bella Gold (Peacotum), Duarte (J. plum), Flavor, **Supreme** (Pluot), Methley (J. plum), Nadia (Pluerry), Satsuma (J. plum), Shiro (J. plum), Waneta (J. x A. plum), Black Ice (J. x Cherry Plum), **Hollywood** (J. plum) and **Superior** (J. x A. plum)
Pear	Chojuro-Shinseike, Bartlett; Nijisseiki (20th Century)-Chojuro, Shinseike, **Bartlett**; Hosui-Partially self-fruitful; Shinseike-Chojuro

Cherry	Index, Lapins, Skeena, Sweetheart, **White Gold**, Sonata, Stella, Symphony, **Sunburst**, and Black Gold
Apricot	Early Blush, SunGem, Tomcot, **Goldstrike, Goldbar, Goldrich** Orangered, Rival Harcot, Goldcot, Hargrande, Harogem, Harglow, Harlayne, Wenatchee-Moorpark, Chinese, Perfection, Tilton
Walnut	Cisco, Scharsch Franquette, **Chandler**, Tulare, **Howard**, Hartley,Tehama
Hazelnut	Birkemeier Farms and Nursery in Canby, Oregon suggests York, **Wepste**r and **Polly O**

Limitations

- Spray-to-harvest
- Cultural practices
- It may confuse pickers, at the time of harvesting resulting in mixed cultivars.
- There also may be an inefficient use of land owing to differences in growth habits

Conclusion

The strategic use of pollinizers is vital for the successful production of temperate fruits, impacting yield, fruit quality, and orchard biodiversity. Proper orchard management, including the selection and placement of pollinizers and support for pollinator activity, can significantly enhance the productivity and sustainability of temperate fruit crops

References

Barzamini S. and Ghazvini R. F., 2017, Pollinizer influence on fruit quality traits in Japanese plum (*Prunus salicina* Lindl.). *Int. J. Horti. Sci. Technol.*, 4(2): 229-237.

Deng L., Wang T., Hu J., Yang X., Yao Y., Jin Z., Huang Z., Sun G., Xiong B., Liao L. and Wang Z., 2022, Effects of pollen sources on fruit set and fruit characteristics of Fengtangli plum (*Prunus salicina* Lindl.) based on microscopic and transcriptomic analysis. *Int. J. Mol. Sci*., 23(21): 01-19.

Kwon S. I., Yoo J., Lee J., Moon Y. S., Choi C., Jung H. Y., Lee D. H., Kim C. K. and Kang I. K., 2015, Evaluation of crab apples for apple production in high-density apple orchards. *J. Plant Biotechnol*., 42(3): 271-276.

Warmund M. R., 2022, Pollinating fruit crops, University of Missouri, Columbia, 1- 4

Raja W. H., Nabi S. U., Kumawat K. L., Sharma O. C. and Singh D. B., 2018, Importance of pollination for temperate fruit crop production. *Indian Farmer,* 5(12): 1458-1463.

Tatari M., Ghasemi A., Mousavi A. and Bahrami H., 2017, Study on pollination and selection of the most suitable pollinizers for commercial pear cultivars (L.) in Iran. *J. Hortic. Research.*, 25(2): 49-57.

Din S., Wani R. A., Nisar F., Farwah S., Rizvi S., Wani T. F. and Nisar S., 2019, Fruit set and development: Pre-requisites and enhancement in temperate fruit crops. *J. Pharmacogn. Phytochem.*, 8(2): 1203-1216.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

CANOPY MANAGEMENT IN GUAVA

Article ID: AG-VO4-I12-77

***Shivaji N Kolekar**

Ph.D Scholar, Fruit science Dr. PDKV Akola, Maharashtra, India

*Corresponding Author Email ID: shivaji.kolekar4@gmail.com

Introduction

It is hardy, prolific bearer and highly remunerative fruit crop and also can be grown satisfactorily even in adverse soil and climatic conditions. The area and production of guava is increasing worldwide, but there is no significant increase in productivity. The canopy management is helpful in achieving the high quality and productivity as well. There is a worldwide trend in fruit producing countries to accommodate maximum number of fruit growth using canopy management and pruning techniques to control the tree growth and tree shape, ultimately limit tree size while still maintaining high fruit production of desired quality. Pruning not only helps to encourage new shoots after the harvest but has also been adapted for rejuvenation of orchards along with crop regulation.

Canopy Management includes the following aspects.,

A) Training and pruning

B) Rootstock and scions

C) High density planting

D) Meadow orcharding

E) Plant growth regulators

Principle of Canopy Management

1. Maximum utilization of light.
2. Avoidance of build-up of micro-climate congenial for the disease and pest.
3. Convenience in carrying out the cultural operations.
4. Maximizing the productivity and quality.

5. Economy in obtaining the required canopy architecture.

Methods of Canopy Management

1. Training and pruning

2. Root stocks & scions

3. High density planting and meadow orcharding

4. Plant growth regulators

Why Canopy Management?

• Canopy management is the manipulation of tree canopies to optimize the production of quality fruits.

• The canopy management, particularly its components like tree training and pruning, affects the quantity of sunlight intercepted by trees, as tree shape determines the presentation of leaf area to incoming radiation.

• An ideal training strategy centers around the arrangement of plant parts, especially, to develop a better plant architecture that optimizes the utilization of sunlight and promotes productivity.

• Managing a canopy will help to develop a better plant architecture, optimizes the utilization of sunlight and increasing fruit production and improving fruit quality in long-term.

• It is important to manage fruit tree canopies to optimize the balance between vegetative growth and fruit production.

•Managing a canopy will help to develop a strong tree that will support heavy crop loads, while increasing fruit production and improving fruit quality in the long-term.

Canopy management in Guava

• Pruning and the use of growth retardants singly or in conjunction can be used to manage the canopies of trees in high density planting situations.

• However, in a high-density planting environment, light and other microclimatic conditions play an important role in guava fruit vegetative development, yield, and quality.

• The guava tree responds well to canopy modification in terms of vegetative and reproductive growth (Singh and Canaan, 2005), canopy modification by pruning and the use of some growth regulators in high-density orchards may be measures to improve production yield.

• Guava leaves have a higher proportion of ‘shade' to ‘sun' leaves, which are photo synthetically inactive under deeper shade and serve as an unproductive drain (Singh and Singh, 2007).

•Untrained or unpruned guava trees become huge and unmanageable after a couple years of growth.

•The bearing area is reduced and the interior of the plant becomes entirely devoid of fruiting.

•Trees are pruned to increase the yield of quality fruits by eliminating crowded and criss-cross branches.

•Pruning begins at an early stage of plant growth to develop single trunk trees with well spaced scaffold branches to form the frame work.

•Apical growth is to be controlled within the first year of planting for better canopy architecture.

•Trees are topped to a uniform height of 60 - 70 cm from the ground level, two-three months after planting to induce the emergence of new growth below the cut point. As a result, new shoots emerge.

•Three to four equally spaced shoots are retained around the stem to form the main scaffold limbs of the tree.

•These shoots are allowed to grow for 4-5 months after topping until they attain a length of about 40 - 50 cm.

•The selected shoots are further pruned to 50 per cent of their length for inducing multiple. shoots from the buds below the cut end.

•Newly emerged shoots are allowed to grow up to 40-50 cm and are pruned again for the emergence of new shoots.

•This is mainly done to obtain the desired shape. The pruning operations continue during the second year after planting.

•After two years, the short branches within the tree canopy produce a compact and strong structure. All the plants are confined to a hedge shape of 2 m inter row width and 2.5m height for which pruning is performed in January-February and May-June every year.

Pruning as part of canopy management

Guava fruit carries on the development of the current season and responds well to pruning. The time of pruning will influence the development season of guavas. Fruit can be picked later if pruning is performed later in the season. There are three basic methods for pruning: thinning, heading out, and pinching or tipping. Thinning entails removing whole trees at the point of origin. Guava fruit continues to grow over the season and reacts well to pruning. Guavas' growth season is influenced by when they are pruned. If pruning is done later in the season, the fruit can be harvested later. Thinning involves cutting whole trees from their original location.

Importance of rootstocks in dense planting & canopy management

High density planting and canopy management will benefit greatly from root stocks and dwarfing cultivars.

1.P. Pupilium

2.Chinese Guava

3.Pusa Srijan (Aneuploid 82)

Guava Needs High Density Planting (HDP)

• Its poor productivity compared to its production capacity.

• Plants with a lot of vegetative growth that responds well to canopy change.

• It has an impact on current season growth, which is very useful for crop management during the year.

Advantages of High-density planting

• Facilitates more productive use of fertilizers and water, particularly during the first 10-15 years;

• High productivity and net returns per unit area of soil, especially during the first 10-15 years.

• The preservation of soil fertility.

• Cost-cutting in the manufacturing process.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

THE SCIENCE BEHIND PLANT-RHIZOBIUM PARTNERSHIPS: A MOLECULAR PERSPECTIVE

Article ID: AG-VO4-I12-78

Keerthana R S*[1] and Jyoti Uppar[2]

[1]Ph. D Scholar, Department of Agricultural Microbiology, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujrat – 396450, India

[2]Ph. D Scholar, Department of Plantation crops and Processing, Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal – 736165, India

*Corresponding Author Email ID: keerthanars2024@gmail.com

Abstract

Legumes are known to establish relationship with nitrogen fixing bacteria in soil, this is called as Rhizobia. As a result of this symbiosis, nodule formation takes place, within that bacteria can convert atmospheric nitrogen into ammonia, so that it can be utilized by plant. The establishment of a successful symbiosis requires the symbiotic partners to be compatible throughout the various stages of their interaction. However, incompatibility often arises, leading to situations where a bacterial strain cannot form nodules on a specific host plant or produces nodules that fail to fix nitrogen effectively. The genetic and molecular mechanisms underlying symbiotic specificity are highly diverse, encompassing a wide array of host and bacterial genes and signals, each operating through distinct modes of action. This aims to provide an updated understanding of the evolution of recognition specificity, particularly in the context of symbiotic signaling and plant responses.

Keywords: Legume-rhizobium symbiosis, nitrogen fixation, Nod factors, flavonoids, nodule organogenesis, plant signaling

Introduction

Symbiosis is a term used to describe a close relationship between two different organisms, which can be mutually beneficial, neutral, or harmful. In the context of and rhizobia, this relationship is primarily mutualistic, meaning both parties gain benefits. Plants, particularly legumes, provide carbohydrates to the bacteria, while the rhizobia help fix atmospheric nitrogen into a form that plants can use. Rhizobium bacteria are essential in sustainable agriculture. By enabling plants to access nitrogen, they reduce the need for chemical fertilizers, contributing to healthier soils and ecosystems. This natural process supports better crop yields and promotes biodiversity, making the partnership invaluable for food production and environmental well-being. Nitrogen fixation is the process by which nitrogen gas present in the atmosphere is converted into ammonia, which plants can utilize for various purpose. Rhizobia play a crucial role here; within root nodules, they convert atmospheric nitrogen into ammonium, aiding plant growth and enhancing soil fertility.

Rhizobium Bacteria: Characteristics and Diversity

1.There are over a hundred species of Rhizobium, each with unique traits to specific leguminous plants. Common types include *Bradyrhizobium japonicum*, *Rhizobium leguminosarum* and *Rhizobium etli*, which associate with different legumes.

2. Metabolic Capabilities of Rhizobium: Rhizobia are adopted for utilizing various carbon sources and can process nutrients in ways that benefit their plant hosts. Their metabolic flexibility allows them to thrive in diverse environments, aiding in their symbiotic role.

3.Adaptations for Symbiosis: These bacteria have evolved structures, like pili and exopolysaccharides, that help them adhere to plant roots and form effective nodules. Such adaptations allow them to thrive in the tough and competitive soil environment.

Plant Hosts: Characteristics and Types

1. Leguminous vs. Non-Leguminous Plants: Leguminous plants, like beans and clover, have a special relationship with rhizobia, forming nodules essential for nitrogen fixation. In contrast, non-leguminous plants do not engage in this partnership, relying instead on different soil nutrients.

2. Root Architecture Variations: The structure of roots can vary significantly among different plant species. Legumes often have specialized root systems designed to maximize rhizobial colonization, which facilitates effective nitrogen fixation.

3. Role of Root Exudates in Attracting Rhizobia: Plants release various organic compounds, known as root exudates, into the soil to attract beneficial microorganisms, including rhizobia. This chemical signaling is the first step in establishing a successful symbiotic relationship.

Molecular Beginnings: The Language of Symbiosis

a) How flavonoids and nod factors facilitate communication between plants and rhizobia?

The symbiotic relationship between legumes and rhizobia is initiated at the molecular level by flavonoids which is essential for nitrogen fixation. When there is nitrogen deficiency in soil, leguminous plants produce and release flavonoids from roots into rhizosphere. These compounds will play an essential role as chemical signals, attracting rhizobia to the plant root and activating specific genes in bacteria, specifically *nod* genes. These genes encode enzymes responsible for synthesizing Nod factors.

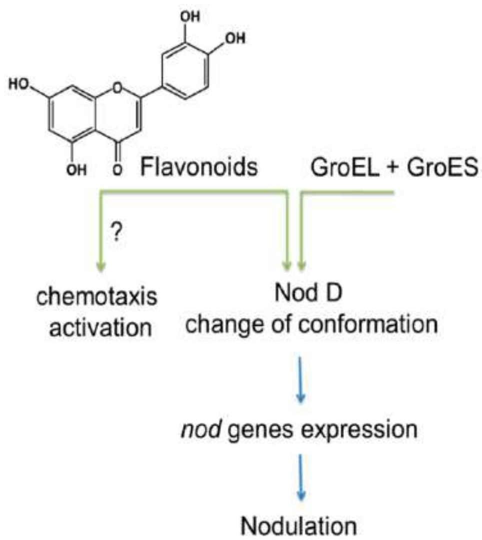


Fig 2: Flavonoids mediate nodulation and the formation of the legume–rhizobia

After recognizing flavonoids, rhizobial NodD proteins (transcriptional regulator) will bind to the flavonoid molecules, which in turn triggers the transcription of *nod* genes. Nod factors are then secreted by rhizobia and perceived by plant root cells through receptors like NFR1 and NFR5. As a result of recognition induces curling of root hairs and formation of infection threads, structures which allows rhizobia to enter cells of roots.

Flavonoids are also responsible for not only for ignition of communication but also known to modulate rhizobial growth dynamics and specificity, ensuring compatibility. This molecular interaction facilitates the establishment of root nodules, where rhizobia fix atmospheric nitrogen into ammonia, benefiting the plant and enhancing soil fertility.

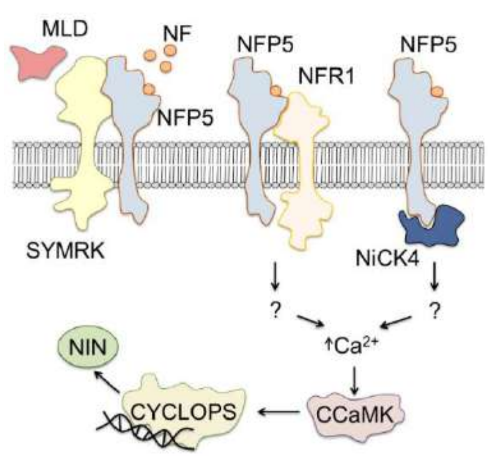
b) How does the activation of Nodulation Protein D (NodD) by specific plant-derived signals influence the mutual recognition process in legume-Rhizobium symbiosis?

Flavonoids like, luteolin, eriodictyol and daidzein interacts with transcriptional regulator NodD, a protein which belong to the LysR family. Plant derived inducers will activate NodD factor which helps to bind to the conserved promoter regions (nod boxes), which will initiate their transcription. The specificity of this interaction is determined by the structure-activity relationship (SAR) of flavonoids. Hydroxyl groups at positions 7 and 4′ are critical for effective nod gene induction, as observed in *Rhizobium leguminosarum* bv. *viciae*. Notably, only inducing flavonoids, such as luteolin, can activate NodD, whereas non-inducing flavonoids act as competitive inhibitors.

In *Sinorhizobium meliloti*, activation of NodD1 and NodD2 requires flavonoids, while NodD3 can function independently. The GroEL protein may facilitate conformational changes in NodD upon flavonoid binding, enhancing its affinity for the nod gene promoter region.

c) What are the key molecular and cellular events involved in the initiation of legume-rhizobia symbiosis?

After release of flavonoids during nitrogen starvation, the initiation of legume-rhizobia symbiosis begins by exchanging the signaling molecules. Flavanoids activate *nod* genes, which leads to the production of Nod factors (NFs), which further determine their compatibility with the host plant. NFs bind to plant receptors like NFR1 and NFR5, triggering a signaling cascade.



This cascade activates key proteins, including SYMRK, CCaMK, and CYCLOPS, which regulate root hair curling, infection thread formation, and nodule primordia development. Calcium signaling plays a central role in modulating these pathways. The infection threads guide rhizobia into the root cortical cells, where they are enclosed in plant-derived membranes to form symbiosomes. Inside symbiosomes, rhizobia differentiate into nitrogen-fixing bacteroids.

Fig 2: Signalling pathways in root cells activated by Nod Factors. (MLD-malectin-like domain, SYMRK-LRR-containing receptor kinase, NF-Nod factors, NFR1 and NRR5-Nod factor receptors 1 & 5, NiCK-NFR5- interacting cytoplasmic kinase 4, CCaMK-calcium/calmodulin-dependent serine/threonine-protien kinase, NIN-nodulation inception transcription factor)

highly coordinated process ensures successful symbiosis, with specific molecular interactions determining host-rhizobia compatibility and efficiency.

d) What are the key signaling mechanisms regulating rhizobial infection and nodule organogenesis in legume roots?

After rhizobia enter the plant root, they get enclosed by the plant cell membrane, forming small chambers called infection chambers. These chambers develop into tube-like structures called infection threads (ITs) that allow rhizobia to move into the root. Proteins like RPG, LIN, VPY, and CBS1 help the IT grow and guide its expansion. The **NIN protein** plays a central role in this process. It activates genes needed for nodulation and triggers root cells to multiply, forming nodules. NIN also increases the levels of a plant hormone called auxin, which further boosts cell division. Another plant hormone, cytokinin, supports NIN activity through its receptor, **CRE1**, helping with nodule development. Strigolactones, another type of plant hormone, are involved in forming and developing nodules, though their exact role is still being studied. NIN also produces **CLE peptides**, which prevent too many nodules from forming, maintaining balance.

Finally, NIN influences **pectate lyase**, an enzyme that makes the root cell walls softer, helping rhizobia enter. These interconnected signals ensure proper infection, nodule formation, and balance, leading to a successful symbiosis between legumes and rhizobia.

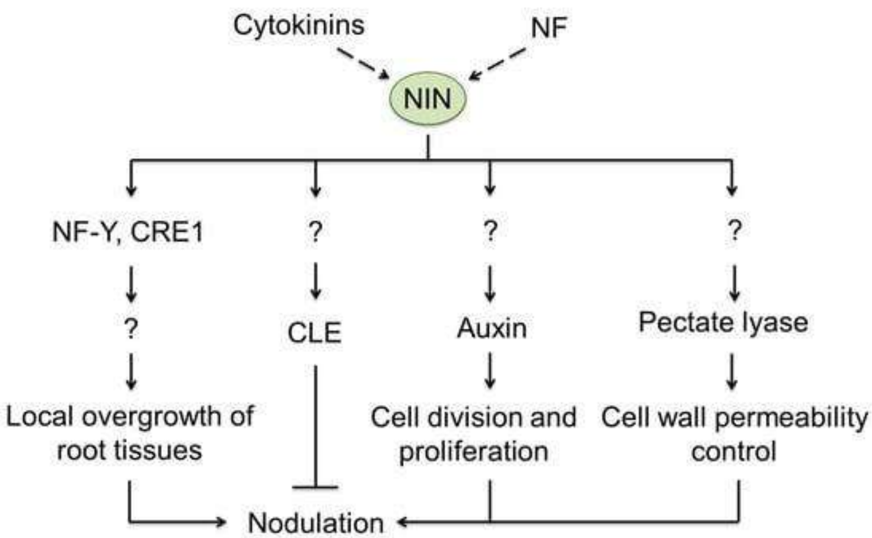


Fig 3. The effects of NIN protein in root cells. NF-Nod factors, NF-Y, nuclear factor-Y, CRE1-Cytokinin response kinase 1, CLE-CLAVATA3/Embryo-surrounding region-related peptides.

e) How do NCR peptides regulate terminal bacteroid differentiation, and what is their role in coordination with autoregulation of nodulation and nodule senescence to ensure effective nitrogen fixation in legumes?

Nodule-specific cysteine-rich (NCR) peptides play a central role in regulating terminal bacteroid differentiation in legumes. These peptides, synthesized by species in the inverted-repeat-lacking clade of Faboideae, induce irreversible differentiation of rhizobia into nitrogen-fixing bacteroids. NCRs achieve this by penetrating bacterial membranes, disrupting cell division, and promoting DNA replication, mediated through proteins like DnaA, GcrA, CtrA, and FtsZ. This differentiation is essential for effective nitrogen fixation within the symbiosome. The diversity of NCR peptides, ranging from seven in *Glycyrrhiza uralensis* to over 600 in *Medicago truncatula*, highlights their species-specific roles in symbiosis.

In parallel, autoregulation of nodulation (AON) ensures energy-efficient nodule formation. CEP peptides, responding to nitrogen availability, trigger nodulation by downregulating TML1/2 inhibitors via miR2111, while CLE peptides limit excessive nodulation by interacting with nodule autoregulation receptor kinases. This balance prevents over-expenditure of plant resources.

As nodules age, NCR peptides integrate with senescence signals to coordinate degradation. Reactive oxygen species, altered redox states, and environmental stresses accelerate senescence, influencing the efficiency of nitrogen fixation. Thus, NCR peptides, AON mechanisms, and nodule senescence collectively ensure optimized nitrogen fixation, balancing plant resource allocation and environmental factors.

Conclusion

Legume–rhizobia symbiosis, understanding still require deeper exploration. These include the molecular mechanisms regulating flavonoid biosynthesis, Nod factor structures, and the identification of additional receptors. Research on signaling pathways, phytohormone roles, and the release of rhizobia into plant cells will be valuable for improving legume productivity. Further studies on nitrogen fixation, nodule development, and senescence will help develop strategies to enhance crop growth and resilience. These efforts are crucial for optimizing legume–rhizobia interactions and advancing sustainable agricultural practices.

References

Wang, Q., Liu, J., and Zhu, H. 2018. Genetic and molecular mechanisms underlying symbiotic specificity in legume-rhizobium interactions. *Frontiers in plant science*, *9*: 313.

Shumilina, J., Soboleva, A., Abakumov, E., Shtark, O. Y., Zhukov, V. A. and Frolov, A. et al. 2023. Signaling in Legume–Rhizobia Symbiosis. *International Journal of Molecular Sciences*, *24(24)*: 17397.

Quilbé, J., Montiel, J., Arrighi, J. F., and Stougaard, J. 2022. Molecular mechanisms of intercellular rhizobial infection: novel findings of an ancient process. *Frontiers in plant science*, *13*: 922982.

Volume: 04 Issue No: 12

FLOWERING, FRUIT SET AND FRUIT DROP AND THEIR MANAGEMENT IN CITRUS

Article ID: AG-VO4-I12-79

***C. Ravindran, R. Manivannan and M. Kavitha**

Associate Professor and Head, Horticultural Research Station, TNAU, Kodaikanal, Dindigul, Tamil Nadu, India

Assistant Professor (Soil Science and Agricultural Chemistry), HRS, TNAU, Kodaikanal

Assistant Professor (Bio-chemistry), RVS Padmavathy College of Horticulture, Semppatti, Dindigul. Tamil Nadu, India

*Corresponding Author Email ID: ravindran.c@tnau.ac.in

Introduction

Citrus is one of the important sub-tropical fruit plants and its group is cultivated throughout the world. The citrus group like Acid group (Acid lime, sour lime, sweet lime), orange group (Sweet orange, mandarin orange), Pummelo and grape fruits were cultivated in different parts of India. The citrus group flowers three times in a year which will be regulated through Bahar treatments (Mrig, Ambe and Hasth Bahar) through with holding of water and other chemicals means to get maximum yield and quality fruits. The flowering behavior, pollination, fruit set and fruit drops are the important parameters deciding the yield in Citrus groups.

Flowering

In citrus any bud is a potential fruit bud and flowering takes place mostly in spring and in growing season when soil moisture and temperature both remain favourable. Although in acid group, limes, lemons, citrons, flower almost through-out the year, two major flushes of flowers usually occur in other species of citrus. The intensity of flowering is influenced greatly by the period of growth cessation, and the amount of the proceeding bloom or crop. In the North Indian conditions, where the temperature goes down substantially during winter months, major bloom of almost all the species occurs during early spring when the atmospheric temperature starts rising after the cold winter and soil moisture condition also improves. In South India, where there is no well-defined winter with very low atmospheric temperature, the flowering season is longer and not very distinct. It is very common to get two crops, occasionally three also, in many citrus types grown in South India. The flowering can, however, be regulated by withholding soil moisture, or through fruit thinning by chemicals and adjustment of fruit harvesting. The practice of withholding water from citrus trees as an aid to promote flowering may cause severe injury to the trees, and hence, use of chemicals is most desirable.

In Israel, Eureka lemons sprayed five times with CCC at a concentration of 1000 ppm, SADH at a concentration of 2500 ppm or BOA at a concentration of 25 ppm considerably increased flowering and production of lemons. BOA was found to be relatively more effective on branches that were older than six months, while CCC and SADH were found to be more effective on branches that were six-month old or younger. Goren and Monselise found chloramphenicol succinate, 5-fluorodeoxyuridine and 5-bromo-3-sec-butyl-6-methyluracil to be effective in inducing flowering in orange. The increased bloom was accompanied by the shortening of internodes which is the characteristic of all flowering branches. Paclobutrazol at 2.5 to 10 g/tree when applied in November to Frost Dancy trees on sour orange rootstocks, reduced shoot length and increased flowering and yield tree from 14-6 kg in the control to 20-4-21-8 kg while in Valencia orange there was a reduction in vegetative vigour with shortening of shoots and internodes. In spite of a small fruit set, yield was significantly increased due to greater blooming. Pruning seems to have little effect on time and amount of bloom. The time of blossom bud differentiation has been found to differ from year to year with climatic variations and also from cultivar to cultivar within a species.

POLLINATION

In general, pollen development is a normal phenomenon in citrus, excepting in a few important citrus cultivars like Washington Navel, Satsuma mandarin, Bearss lime, etc., where no viable pollen is produced. Variation in the longevity of pollen grains of different citrus species and the pollen grains from mature buds of *C. medica* had higher germination potentiality than the dehisced ones. The cultivars where pollen is produced in abundance, self-pollination is a general rule. However, in orchard with mixed planting of different cultivars, cross pollination is not uncommon. The stigma remains receptive for 6-8 days. Honey bees are known to act as the pollinating agent in citrus. Cross pollination is increase seediness in certain citrus cultivars like

Shamouti orange, Clementine mandarin and Mineola tangelo and it has been reported that in the later two cultivars cross-pollination has resulted in increased fruit yield. In Washington Navel and Marsh Seedless grape- fruit also hand pollination with pollen from seedy cultivars had been reported to cause better fruit set. Both male and female sterility, partial self-incompatibility and normal male and female fertility conditions prevailing in the genus Citrus which have resulted to different degree of seediness in the fruits and in general citrus fruits fall in the broad categories of seedless, commercially seedless and seedy classes.

Self-incompatibility has been occurred in several species of citrus, such as Siamese pummelo, Orlando tangelo, Italior, Nepali Oblong and Lucknow Seed- less lemon, pummelo, Clementine mandarin and sweet lime, but Nagpur Santra was found to be self-compatible and cross compatible except with grapefruit. Venkateswarlu and Lavania reported that cross-pollination of Pant Lemon-1 with different pollen parents resulted in very high fruit set and fruit retention as compared with that obtained through hand-selfing, natural selfing and open-pollination. Of all pollen parents, Italian and Nepali Oblong lemons were found to be the best pollinizers for Pant Lemon-1.

FRUIT SET

In most citrus species, poor fruit set and high fruit drop result in poor yield, especially unfavorable environmental conditions, such frosts and drought etc. During summer months there is considerable, loss of soil moisture resulting in severe drop of fruits. Mulching with leaves or black polythene has been found to reduce fruit drop. Many growth regulators have been used in citrus with varying degree of success. A spray of 2, 4-D and 2, 4, 5-T has been found to increase fruit set markedly and improved the size and quality of fruits in mandarin. Titratable acidity, ascorbic acid and sugar content of the fruit increased as a result of treatment with 2, 4-D, 2, 4, 5-T or NAA. 2, 4, 5-T at 10 and 15 ppm increased fruit set over control in Pineapple and Valencia Late orange.

Increase in fruit set resulted when GAs was applied to flowers or to individual fruits of Bearss lime, Eureka lemon and Washington Navel orange. In otherwise, gibberellin sprays had been found beneficial in Clementine mandarin, Valencia orange, grapefruit, sweet lime, Jaffa and Pineapple sweet oranges. Although increased fruit set has been achieved as a result of treatment with GA3, some undesirable effects of gibberellin treatment on fruit quality was also recorded.

Thus, gibberellin-treated fruits have rough and thick skin and are less juicy as compared with untreated fruits.

FRUIT DROP

High rate of fruit drop is a serious problem of citrus in India. Many chemicals have been tried to reduce fruit drop. While NAA was found ineffective in reducing fruit drop in Washington Navel oranges, 2, 4-D is very effective in reducing or preventing pre-harvest drop of citrus, mainly because it delays development of abscission zone on the fruit stem. An application of 2, 4-D at a concentration of 8 ppm, when the Valencia orange fruits are 0-5 inch in diameter, reduced the drop of mature fruits. Similarly, spray of 2, 4-D at 60 ppm applied in June or July reduced fruit drop during summer or early fall. Investigations done at IARI revealed that 2, 4, 5-T was effective in Jaffa and Mosambi and in Pineapple 2, 4-D was most effective when spraying was done in October. Similarly, GA3 at 50 ppm and 75 ppm was effective in Jaffa and Pineapple respectively, in reducing June drop. The gibberellic acid, 2, 4-D and 2, 4, 5-T being effective in reducing fruit drop in sweet lime, while GA3 and 2, 4-D proved effective in reducing fruit drop in Darjeeling mandarin.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

ARTIFICIAL INTELLIGENCE IN AGRICULTURE AND ITS APPLICATIONS

Article ID: AG-VO4-I12-80

***Arpitha Karadi[1], Vangala Navya[1], Sujatha Patta[2]**

[1]Ph. D Scholar, Department of Seed Science and Technology, Professor Jayashankar Telangana Agricultural Univeristy, Telangana state, India

[2]Dr. P. Sujatha, Associate Professor, Professor Jayashankar Telangana Agricultural Univeristy, Telangana state, India

*Corresponding Author Email ID: arpithakaradi18@gmail.com

Abstract

Artificial Intelligence (AI) is profoundly transforming industries worldwide, and agriculture is no exception. By combining cutting-edge technologies like machine learning, computer vision, and big data analytics, AI addresses challenges in agriculture, such as resource scarcity, climate change, and increasing food demand. This document explores the integration of AI in agriculture, its benefits, applications, challenges, and the future of smart farming.

Introduction

Artificial Intelligence (AI) has revolutionized agriculture by introducing smart technologies that enhance productivity, efficiency, and sustainability. AI applications range from precision farming to crop monitoring, pest control, and predictive analytics. Through machine learning, computer vision, and robotics, AI enables real-time data collection and decision-making, optimizing resource use and minimizing waste.

AI-powered tools like drones and satellite imagery assist in monitoring crop health, detecting diseases, and managing irrigation. Predictive models analyze historical and real-time data to forecast weather patterns, yields, and market trends, aiding farmers in planning and risk management. Autonomous machinery, such as self-driving tractors and robotic harvesters, streamlines labor-intensive tasks. These innovations address global challenges such as food security, labor shortages, and climate change, making agriculture more sustainable and resilient.

AI in Agriculture: Key Roles and Applications

1. **Precision Farming**

   AI analyzes data from sensors, drones, and satellites to monitor soil conditions, crop health, and weather patterns. Farmers use these insights to optimize irrigation, fertilization, and pesticide application, reducing waste.

2. **Crop Monitoring and Health Analysis**

   Computer vision systems and AI models detect diseases, pests, and nutrient deficiencies in crops early. This minimizes losses and ensures timely intervention. AI-enabled drones assess large fields for early disease detection.

3. **Autonomous Farming Equipment**

   AI powers self-driving tractors, harvesters, and weeding robots to automate labor-intensive tasks. This improves efficiency and reduces dependence on human labor.

4. **Predictive Analytics**

   Machine learning algorithms forecast weather conditions, yield potential, and market trends. Farmers use these predictions for better crop planning and risk management.

5. **Smart Irrigation Systems**

   AI integrates with IoT devices to monitor soil moisture and weather, ensuring precise water usage. This conserves water and prevents over-irrigation.

6. **Supply Chain Optimization**

   AI optimizes logistics, storage, and distribution, reducing food waste and ensuring timely delivery.

7. **Climate-Resilient Farming**

   AI models assess climate data and recommend adaptive farming practices to mitigate the effects of climate change.

BENEFITS OF AI IN AGRICULTURE

1. **Enhanced Crop Productivity**: AI technologies enable precise monitoring and analysis of crop health, leading to improved yields.
2. **Efficient Resource Management**: AI-powered systems optimize the use of water, fertilizers, and pesticides, reducing waste and lowering input costs.

3. **Early Detection of Problems**: AI detects pests, diseases, and nutrient deficiencies in crops, allowing farmers to take timely corrective actions.
4. **Automation of Labor-Intensive Tasks**: Autonomous machinery, such as AI-driven tractors and robotic harvesters, reduces reliance on manual labor.
5. **Accurate Weather Forecasting**: AI provides precise weather predictions, enabling farmers to plan agricultural activities effectively and mitigate risks.
6. **Sustainability and Environmental Conservation**: AI promotes eco-friendly practices by minimizing resource overuse and reducing environmental impact.
7. **Cost Efficiency**: By streamlining farming operations and minimizing losses, AI helps cut operational costs.
8. **Real-Time Monitoring and Insights**: AI-powered drones and IoT devices provide real-time data on soil health, crop growth, and environmental conditions.
9. **Reduced Post-Harvest Losses**: AI optimizes the food supply chain by improving storage, transportation, and distribution processes.
10. **Adaptation to Climate Change**: AI tools assist in selecting resilient crops and adapting farming practices to cope with changing climate conditions.

These benefits demonstrate how AI fosters innovation in agriculture, ensuring food security and sustainable practices.

CHALLENGES OF AI IN AGRICULTURE

1. **High Implementation Costs**: Developing and deploying AI technologies require significant investment, making it difficult for small-scale farmers to adopt.
2. **Limited Technological Infrastructure**: Many rural areas lack access to reliable internet and advanced technological infrastructure needed for AI systems.
3. **Data Availability and Quality**: AI relies on large, high-quality datasets, but inconsistent or limited agricultural data can hinder accurate decision-making.
4. **Skill Gap**: Farmers often lack the technical knowledge and skills to operate AI tools, necessitating extensive training and support.
5. **Integration Challenges**: Merging AI with existing agricultural practices and systems can be complex and time-consuming.
6. **Privacy and Data Security**: The collection and use of data raise concerns about farmer privacy and the security of sensitive information.

7. **Environmental Variability**: AI models may struggle to adapt to the unpredictable nature of farming environments, such as extreme weather or diverse soil conditions.
8. **Dependence on Connectivity**: AI systems often require continuous connectivity, which is a challenge in remote and underdeveloped regions.
9. **Resistance to Adoption**: Farmers may be hesitant to adopt AI due to distrust of new technologies or fear of job displacement.
10. **Ethical Concerns**: The use of AI raises ethical questions about labor displacement and the role of technology in traditional farming communities.

FUTURE OF ARTIFICIAL INTELLIGGENCE IN AGRICULTURE

1. AI will optimize logistics and reduce post-harvest losses by streamlining storage, transportation, and distribution, ensuring food security.
2. AI applications providing farmers with tailored insights based on specific geographic and environmental conditions, improving decision-making at the local level.
3. Enabling faster detection of crop diseases, pests, and nutrient deficiencies using advanced sensors and computer vision, allowing timely interventions.
4. Integration with Smart Cities and Global Food Systems: AI-driven agriculture is expected to integrate with urban farming initiatives and global food systems, ensuring efficient food production and distribution in growing urban populations.
5. Development of Agri-Tech Startups: The increasing adoption of AI in agriculture will encourage innovation and the growth of startups focused on AI-based solutions for farming challenges.
6. AI-Driven Sustainability: AI will promote environmentally sustainable practices by optimizing resource use, reducing emissions, and minimizing waste, contributing to global sustainability goals.
7. Data-Driven Farming Revolution: With advancements in big data analytics, AI will empower farmers to harness large datasets for predictive analytics, yield optimization, and market insights.

Conclusion

Artificial Intelligence is poised to play a transformative role in the future of agriculture. By enabling more precise, efficient, and sustainable farming practices, AI has the potential to address many of the challenges faced by the agricultural industry, such as climate change, labor shortages, and food security. Through innovations like precision farming, autonomous machinery, and real-time crop monitoring, AI can significantly enhance productivity and reduce resource wastage. Moreover, AI's ability to analyze large datasets and predict outcomes allows farmers to make informed decisions, optimize operations, and mitigate risks. As AI technologies continue to evolve, their integration with other emerging technologies like IoT and blockchain will further enhance the efficiency of food production, distribution, and supply chains.

However, the widespread adoption of AI in agriculture faces challenges, including high implementation costs, the need for technical expertise, and concerns about data privacy. Despite these hurdles, the future of AI in agriculture looks promising, with the potential to revolutionize farming practices, improve environmental sustainability, and contribute to the global food supply. In conclusion, AI is not just a tool for improving agricultural output; it is a catalyst for a more sustainable and resilient agricultural system that can meet the growing demands of the global population.

References

Wolfert, S., Ge, L., Verdouw, C and Bogaardt, M. J. (2017). Big Data in Smart Farming. *Agricultural Systems*. 153: 69-80.

Liakos, K. G., Busato, P., Moshou, D., Pearson, S and Bochtis, D. (2018). Machine Learning in Agriculture: A Review. *Sensors*. 18(8): 2674.

Kamilaris, A., Kartakoullis, A and Prenafeta-Bolduu, F. X. (2017). A Review on the Practice of Big Data Analysis in Agriculture. *Computers and Electronics in Agriculture*. 143: 23-37.

Shadrin, D., Menshchikov, A., Somov, A., Bornemann, G., Hauslage, J and Fedorov, M. (2019). Enabling precision agriculture through embedded sensing with artificial intelligence. *IEEE Transactions on Instrumentation and Measurement*. 69(7): 4103-4113.

Subeesh, A and Mehta, C. R. (2021). Automation and digitization of agriculture using artificial intelligence and internet of things. *Artificial Intelligence in Agriculture*. 5: 278-291.

Meshram, V., Patil, K., Meshram, V., Hanchate, D and Ramkteke, S. D. (2021). Machine learning in agriculture domain: A state-of-art survey. *Artificial Intelligence in the Life Sciences*. 1:100010.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

EDUCATIONAL PROGRAMS IN INDIA

Article ID: AG-V04-I12-81

***Elizabeth Martin[1] and Geeta Channal[2]**

1. Ph.D. Scholar, Department of Food and Nutrition, College of Community Science, University of Agricultural sciences, Dharwad, 580005.
2. Associate professor, Department of Extention Education and Communication Management, College of Community Science, University of Agricultural sciences, Dharwad, 580005. Karnataka, India

*Corresponding Author Email ID: elzi2135@gmail.com

Introduction

India's educational landscape has seen transformative changes over the past few decades, driven by government initiatives to improve access, equity and quality of education. Various educational programs have been launched to address the diverse challenges faced by the country's vast population, such as low enrolment, high dropout rates and disparities in access to education for marginalized communities. This article evaluates the impact of key educational programs in India, examining their successes, challenges and areas where improvements are still needed.

Major Educational Programs in India

Several flagship programs have been pivotal in shaping India's education sector:

1. **Sarva Shiksha Abhiyan (SSA)**: Launched in 2001, SSA aims to provide universal elementary education to children aged 6-14. It focuses on increasing enrollment, retention and improving the quality of education in schools.
2. **Mid-Day Meal Scheme (MDMS)**: Introduced in 1995, this program provides free meals to school children in government schools. It aims to enhance school attendance, reduce hunger and improve nutritional intake among children.
3. **Rashtriya Madhyamik Shiksha Abhiyan (RMSA)**: Started in 2009, RMSA focuses

on improving access to quality secondary education by increasing the number of secondary schools and providing resources for infrastructure and teaching.

4. **Right to Education (RTE) Act**: Implemented in 2010, the RTE Act makes educationa fundamental right for children aged 6-14, mandating free and compulsory education in all government schools.
5. **Digital India and e-learning initiatives**: Programs such as DIKSHA, SWAYAM and ePathshala aim to promote digital learning and make educational resources available online to students and teachers across the country.
6. **National Education Policy (NEP) 2020**: A landmark policy introduced to overhaul India's education system, the NEP 2020 emphasizes holistic development, flexibility in learning, vocational training and the integration of technology in education.

Positive Impacts

1. **Increased Enrollment and Access**: One of the most significant impacts of educational programs, particularly Sarva Shiksha Abhiyan and the RTE Act, has been the rise in

school enrollment. According to the National Statistical Office (NSO) survey, the Gross Enrollment Ratio (GER) in elementary education increased significantly, with near-universal enrollment at the primary level.

2. **Reduction in Gender Disparities**: Programs such as Beti Bachao, Beti Padhao and SSA have contributed to closing the gender gap in education. The school enrollment of girls has improved markedly and the gender parity index at the elementary level has reached almost 1, indicating equal enrollment of boys and girls.
3. **Impact of the Mid-Day Meal Scheme**: The MDMS has successfully addressed hunger and malnutrition among school-going children. By providing nutritious meals, the scheme has positively influenced school attendance, especially in rural areas. Studies show that children who receive mid-day meals tend to have better concentration, learning outcomes and retention rates.
4. **Improved Literacy Rates**: India has witnessed a steady improvement in literacy rates, with a noticeable increase in female literacy. Educational programs focused on adult education and literacy, such as the National Literacy Mission (NLM), have played a significant role in promoting literacy in rural and underserved areas.
5. **Increased Focus on Secondary Education**: RMSA has expanded access to secondary education by improving school infrastructure, appointing qualified teachers and offering financial support for marginalized groups. GER at the secondary level has also improved, contributing to higher completion rates.
6. **Introduction of Technology in Education**: Digital initiatives like DIKSHA and SWAYAM have revolutionized education, especially during the COVID-19 pandemic. These platforms have made quality content accessible to students and teachers, enabling remote learning and supplementing traditional teaching methods.
7. **Skill Development and Vocational Training**: The NEP 2020 focuses on imparting vocational training and promoting holistic education. The emphasis on creativity, critical thinking and life skills aims to prepare students for future job markets and bridge the skill gap in the economy.

Challenges Faced by Educational Programs

1. **Quality of Education**: While access to education has improved, the quality of education remains a concern. Several reports, including the Annual Status of Education

Report (ASER), reveal that many students in rural areas lack basic literacy and numeracy skills even after several years of schooling. The gap between enrollment and actual learning outcomes continues to be significant.

2. **High Dropout Rates**: Despite improvements in enrollment, dropout rates, particularly in secondary education, remain high. Economic factors, child labour, early marriages and lack of family support often force children, especially girls, to discontinue their education.
3. **Inequities in Access**: Although programs like SSA and RMSA aim to provide equitable access to education, regional and socioeconomic disparities persist. Children from marginalized communities, including Scheduled Castes, Scheduled Tribes and economically weaker sections, often face barriers such as poor infrastructure, lack of qualified teachers and inadequate resources.
4. **Teacher Quality and Shortages**: Teacher shortages and the lack of adequately trained educators, particularly in rural and remote areas, affect the effectiveness of educational programs. Many teachers face challenges in implementing new pedagogical techniques, especially with the growing focus on digital and blended learning.
5. **Digital Divide**: While digital learning initiatives have gained prominence, the digital divide continues to widen the gap between students with access to technology and those without. Rural areas, in particular, face challenges in accessing e-learning resources due to a lack of infrastructure, internet connectivity and digital literacy.
6. **Monitoring and Accountability**: Many educational programs suffer from inadequate monitoring and accountability mechanisms. Corruption, mismanagement of funds and lack of transparency in the implementation of programs reduce their impact and effectiveness.

Areas for Improvement

1. **Improving Learning Outcomes**: Educational programs must focus more on learning outcomes than merely increasing enrollment. Enhanced teacher training, continuous professional development and a focus on foundational literacy and numeracy will help improve the quality of education.
2. **Addressing Dropout Rates**: Economic support through scholarships and conditional cash transfers, along with community engagement, can help reduce dropout rates.

Programs must focus on the unique needs of girls, children from marginalized communities and those with disabilities to ensure their continued participation in education.

3. **Bridging the Digital Divide**: The government should prioritize expanding internet access and providing digital devices to students in rural areas. Additionally, training teachers and students in digital literacy is essential for the successful integration of technology in education.
4. **Strengthening Vocational Education**: With the growing emphasis on skill development in NEP 2020, educational programs should further expand vocational training and apprenticeship opportunities to ensure that students are equipped with skills relevant to the labour market.
5. **Ensuring Equity and Inclusion**: Programs must prioritize equity by addressing the unique challenges faced by marginalized groups. This includes providing resources, support systems and inclusive teaching practices that cater to diverse learning needs.
6. **Enhancing Monitoring and Evaluation**: Robust monitoring mechanisms and accountability measures are crucial to ensuring the effective implementation of educational programs. Data-driven policies and real-time assessments can help address gaps in program delivery and resource allocation.

Conclusion

India's educational programs have made significant strides in improving access, equity and quality, particularly at the elementary and secondary levels. However, the challenges of poor learning outcomes, high dropout rates and regional disparities remain persistent. The future of India's education sector depends on continued investment in teacher quality, digital infrastructure and vocational training, alongside stronger efforts to address inequities. The National Education Policy 2020 offers a progressive vision, but its successful implementation will require coordinated efforts between government, educators and communities.

Volume: 04 Issue No: 12

CARBON FARMING: CULTIVATING SOLUTIONS FOR CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

Article ID: AG-VO4-I12-82

***Vangala Navya, Arpitha Karadi and Sujatha Patta**

Ph.D Scholar (Seed Science and Technology), Professor Jayashankar Telangana Agricultural Univeristy, Telangana state, India

*Corresponding Author Email ID: vangalanavya.8@gmail.com

Abstract

Carbon farming represents a transformative approach to address climate challenges by enhancing the capacity of soil and vegetation to store atmospheric carbon. By employing innovative practices, it not only reduces greenhouse gases but also promotes healthier ecosystems and more resilient farming systems. Methods like no-till cultivation and integrating trees into agricultural landscapes contribute to improving soil quality and supporting long-term productivity. Despite its potential, the widespread adoption of carbon-focused agricultural practices faces several obstacles. Economic challenges, such as the upfront costs of implementation, paired with a lack of access to reliable information and resources, often deter farmers. Additionally, navigating complex regulatory frameworks and uncertainty around carbon credit markets further complicates participation. Solutions such as streamlining policies, providing targeted financial support, and offering accessible education and training programs are essential to overcoming these hurdles and encouraging greater involvement.

Introduction

Carbon farming is a set of land management practices aimed at reducing atmospheric carbon dioxide (CO_2) and storing it in natural sinks such as soil and vegetation. These practices enhance soil organic carbon, improve biodiversity, and contribute to sustainable agriculture. Methods such as no-till farming, agroforestry, and the use of biochar are central to carbon farming, offering dual benefits of climate mitigation and improved soil health. As climate change becomes a bigger challenge, agriculture plays a double role, it contributes to greenhouse gas emissions but also holds the key to solutions. Carbon farming is a powerful way to fight climate change by using farming practices that capture and store carbon in the soil and plants. This approach not only helps reduce harmful emissions but also makes farms more sustainable and productive.

The agricultural sector is a key player in global climate dynamics, contributing nearly 24% of green house gas emissions through activities like deforestation, soil degradation, and methane emissions from livestock. However, carbon farming practices can help counteract these impacts. One such practice is no-till cropping, which minimizes soil disturbance, preserving organic matter and reducing carbon loss from the soil. This method enhances soil fertility and supports sustainable yields over time. Similarly, agroforestry, which integrates trees into farming systems, boosts carbon sequestration while creating diverse habitats that improve ecosystem health. Biochar, a charcoal-like substance added to soil, enhances its ability to retain nutrients and water, reducing reliance on chemical inputs and improving crop productivity. These methods not only reduce emissions but also deliver co-benefits such as improved water retention, reduced erosion, and enhanced biodiversity.

Carbon farming has broader implications beyond climate mitigation. It plays a crucial role in restoring degraded lands, improving soil structure, and increasing agricultural resilience against extreme weather events. Farmers who adopt these practices often experience long-term economic benefits, such as reduced input costs and improved crop yields. Moreover, the integration of these practices can contribute in achieving global sustainability goals by balancing food production with environmental conservation.By transforming traditional farming into a tool for climate action, carbon farming offers a promising path to sustainable agriculture. Its ability to simultaneously address environmental challenges and support farm productivity makes it a critical solution in the fight against climate change. Through widespread adoption, carbon farming could help reshape agriculture into a force for environmental restoration and resilience.

The Science Behind Carbon Farming:

Carbon farming leverages the natural processes of carbon sequestration to reduce greenhouse gas levels in the atmosphere and improve soil health. At its core, carbon farming focuses on enhancing the soil carbon pool, a critical component of the global carbon cycle. Agricultural soils can act as significant carbon sinks, storing carbon dioxide (CO_2) captured from the atmosphere through plant photosynthesis and converting it into organic matter within the soil.Key practices such as no-till farming, cover cropping, and agroforestry play a pivotal role in increasing soil organic carbon. No-till farming minimizes soil disturbance, preventing carbon loss and enhancing microbial activity that supports carbon storage. Cover crops contribute additional biomass, protecting soil carbon from erosion and promoting aggregation, which locks carbon within the soil structure. Agroforestry integrates trees and shrubs into farming systems, which not only sequester carbon in their biomass but also improve soil stability and fertility.

The amount of carbon that can be sequestered varies based on factors such as soil type, climate, crop rotation, and management practices. For example, transitioning from conventional tillage to no-till practices has been shown to increase soil organic carbon significantly over time, while the use of cover crops can boost carbon inputs to the soil by adding organic matter. However, achieving measurable impacts often requires long-term commitment to these practices, as soil carbon levels increase gradually over many years.While the potential for carbon farming to mitigate climate change is substantial, the science also acknowledges its limitations. Soil carbon sequestration is not permanent and can be reversed through practices like over-tillage or land-use changes. Despite these challenges, carbon farming remains a promising approach to addressing climate change while simultaneously improving agricultural productivity and sustainability.

Challenges in Carbon Farming:

Carbon farming faces several challenges that hinder its widespread adoption. Many farmers lack awareness and understanding of its benefits and practices, which leads to hesitation in implementation. The high initial costs associated with equipment, training, and preparation further discourage participation, especially for small-scale farmers. Policy inconsistencies and unclear regulations surrounding carbon credits create confusion and reduce confidence in its economic viability. Fluctuating carbon prices and unstable market structures also make it difficult for farmers to rely on carbon farming as a sustainable income source. Monitoring and verifying carbon sequestration progress is another hurdle, as it requires complex and costly processes. Resistance to change from traditional farming practices and skepticism about new methods add to the difficulty. Additionally, inadequate institutional support, limited access to advisory services, and regional environmental constraints, such as soil type and climate, complicate the successful implementation of carbon farming practices. Overcoming these challenges will require better education, financial incentives, and policy reforms.

Policies and Incentives:

Policy and incentives are essential to scaling carbon farming practices and integrating them into mainstream agriculture. Governments and organizations play a key role by offering financial rewards and creating supportive frameworks that encourage farmers to adopt sustainable land management techniques. Programs like Australia's Emissions Reduction Fund (ERF) and Land Restoration Fund (LRF) highlight how strategic initiatives can provide economic benefits to farmers while enhancing environmental outcomes. These programs reward efforts such as preventing deforestation, regenerating vegetation, and increasing soil carbon storage, making carbon farming both viable and appealing to landholders.

A strong focus on co-benefits—such as biodiversity conservation, improved water quality, and healthier soils—adds further value to carbon farming projects. By aligning these ecological gains with financial incentives, policymakers create additional motivation for farmers to participate. Transparent monitoring and verification systems also ensure the credibility of carbon credits and help build trust in the market. Simplifying the regulatory landscape and establishing fair pricing mechanisms for carbon credits can address some of the current barriers, fostering broader participation. While, challenges like market uncertainties and administrative burdens persist, well-crafted policies can drive change by reducing complexities, offering subsidies, and investing in education and outreach. These measures empower farmers to adopt carbon farming, ultimately transforming agriculture into a key tool for combating climate change and promoting sustainability.

Conclusion

Carbon farming offers a promising path to addressing climate change while enhancing agricultural sustainability. By leveraging innovative practices, it has the potential to transform agriculture into a key solution for reducing greenhouse gases and improving ecosystem health. However, its success depends on overcoming the barriers of cost, complexity, and accessibility. To unlock its full potential, collaboration among policymakers, farmers, and researchers is crucial. Streamlined policies, robust financial incentives, and widespread education can empower more farmers to adopt carbon-focused techniques. With the right support, carbon farming can become a cornerstone of global efforts to combat climate change and build a more resilient and sustainable agricultural future.

References

Sharma, M., Kaushal, R., Kaushik, P., & Ramakrishna, S. (2021). Carbon farming: Prospects and challenges. *Sustainability*, *13*(19), 11122.

Dumbrell, N. P., Kragt, M. E., & Gibson, F. L. (2016). What carbon farming activities are farmers likely to adopt? A best–worst scaling survey. *Land Use Policy*, *54*, 29-37.

Bumbiere, K., Sanchez, F. A. D., Pubule, J., & Blumberga, D. (2022). Development and assessment of carbon farming solutions. *Environmental and Climate Technologies*, *26*(1), 898-916.

Baumber, A., Waters, C., Cross, R., Metternicht, G., & Simpson, M. (2020). Carbon farming for resilient rangelands: people, paddocks and policy. *The Rangeland Journal*, *42*(5), 293-307.

Thompson, N. M., Hughes, M. N., Nuworsu, E. K., Reeling, C. J., Armstrong, S. D., Mintert, J. R., ... & Foster, K. A. (2022). Opportunities and challenges associated with "carbon farming" for US row-crop producers. *Choices*, *37*(3), 1-10.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

HARNESSING THE NATURAL ENERGY THROUGH NATUECO FARMING

Article ID: AG-VO4-I12-83

S. Saravanakumar*

Scientist (Agronomy), ICAR – Krishi Vigyan Kendra, MYRADA

Erode District, Tamil Nadu, India

*Corresponding Author Email ID: myradakvkagri@gmail.com

Introduction

Nature has developed its ecology and continues to do so since billions of years, by utilizing its own resources within their availability; without depending on any external resources and creating an abundance in its ecosystem. With its abundance, this ecosystem nurtures higher and higher complexities of life processes throughout their evolution. Natueco Culture is a scientifically developed Farming system taking clues from this trait of the Nature, aimed towards abundance without external inputs to a farm and keeping the scope of enhancement of knowledge wide open through individual experiments and experiences.

Natueco Science is a science of harvesting maximum Sunlight available on earths per square foot of area using farming as a medium. The focus is on conservation of energy than on mere farm output by weight. It emphasizes optimal and efficient use of soil, water and labour. The Natueco farming system is a farming practice which involves effective and efficient use of the available resources within the farm vicinity to enhance and enrich the ecosystem without exploiting it, thus making a farmer prosperous with equality and liberty. Natueco Farming Science is a (healthy) way of farming through scientific methods by using less space, less water and natural resources from surrounding areas in accordance with changes in the environment. Its aim is the protection of environment and the prosperity of the farmer families. This method is developed by combining old and new natural methods and scientific methods of agriculture. It has resulted in more and better yield at lesser cost.

Thus, Natueco Farming emphasizes on `Neighbourhood Resource Enrichment' by `Additive Regeneration' rather than through dependence on external and commercial inputs. It focuses on the **four main areas** of a plant for a good quality crop.

SOIL-Create a soil with best primary productivity by recycling the biomass and by establishing a proper energy chain.

ROOTS-Focus on development and maintenance of white root zones of the plant for efficient absorption of nutrients.

CANOPY-Focus on harvesting the sun light by proper plant canopy management for efficient photosynthesis.

EXTERNAL RESOURCES-Focus on minimizing the use of external resources including water to reduce dependency on the secondary productivity of the soil.

It maximizes farm output with minimum input in energy terms. Its goal is to maximize carbon or biomass of the soil (factors of Primary productivity).

In Natueco cultivation harvesting of Sun energy is given prime importance, coupled with nursery soil built up through use of all the plant parts. In Natueco, one needs to understand the principles on his/her own initiatives, innovating continuously with scientific knowledge. Once this attitude is established, Natueco promises "Plenty for all".

Basic principles of Natueco

- The first principle of Natueco culture is the establishment of canopy index of a plant at the earliest so that the plant will be capable of taking full advantage of the Sunlight it has to harvest.
- The second important principle is that only matured leaves of a plant are capable of optimum harvesting of Sunlight.
- The third important principle for having optimum photosynthesis in Nature is that there should be matching storage organ growth in plants at the time when optimum photosynthesis is taking place in the matured leaves.

Symbiotic Relationship with Nature & Ecology

1. It is the eternal truth that Nature's intelligence is the most superior among all the intelligences. So we must develop farming by mimicking Nature.
2. Natueco follows the principles of eco-system networking of Nature.
3. Natueco offers an alternative to commercial and heavily chemical dependant farming.

4. Natueco emphasizes the harvesting of sunlight through critical application of scientific examination, experiments and methods that are rooted in neighbourhood resources.
5. Natueco "demystifies science" by developing a thorough understanding of plant physiology, biology, geometry of growth, physics, fertility and biochemistry.

Components of natueco farm

The major and important components of a Natueco farm are

1. Natueco Soil
2. Knowledge base
3. Seed treatment
4. Bio-diversity
5. Live fencing
6. Data base

Bio-diversity is achieved in a Natueco farm through a concept of multi-layer, multi-tyre crop cultivation. In a limited area one can grow plants of different height (from similar habitat) in a cluster which can give diversity in produce according to our needs. This also benefits the plants to create a symbiotic relationship with each other also reduces the water requirement of plants by capturing humidity within that area.

Two effective models of such integrated plantation are created in the Natueco farming with a biodiversity on a limited area to benefit small farmers/ house gardens to produce the daily food requirement of a family in an effective way.

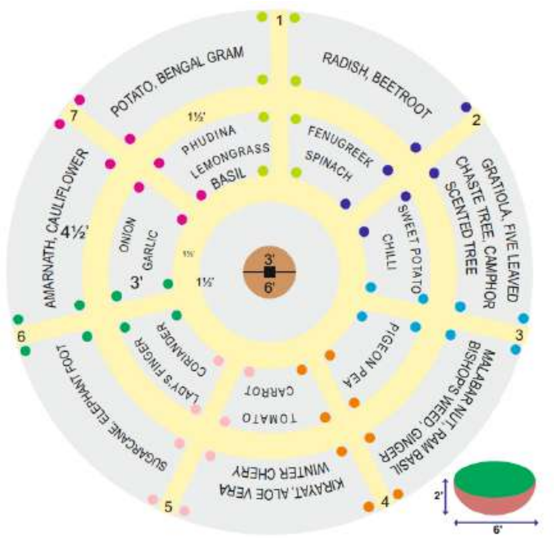
Ganga Maa Mandal

This model was developed by a South Indian housewife. She developed the model for sustaining her family's nutritional requirement and also empowered herself through adding income to her family with minimum efforts by only utilizing the neighbourhood resources to an optimum level. Bill Mollison, the agriculturist, proposed this model for domestic farming by every woman of a family to eradicate malnutrition and death of infants in underprivileged

families. In this model production starts from 3 month onwards and full cycle completion requires 1.5 years.

Objectives

Fulfil the nutritional need of underprivileged families by optimum utilization of neighbourhood resources.



TEN GUNTHA model

Ten Guntha is a term for a physical area of 10,000 sq. ft. in Western India. This is also the name given to a model of farming that can sustain the livelihood of a 5 member family catering to all the nutritional needs of the family members. It not only gives the family food security but also fulfils other requirements to lead a graceful life with Liberty and Prosperity.

Ten Guntha model is the art of sunlight networking to get optimum yield and prosperity based on Natueco Science farming. It requires 8 hours labour work a day for the first 3 years and only 2 hours a day after that. A Ten Guntha model becomes sustainable within 3 years.

Objectives

- Fulfil the Nutrition and Calories value needed by a 5 member family for a healthy life.
- Fulfil all other farm related requirements of a 5 member family.
- Raise the living standards of marginal farmers to a middle class level.
- Ensure marginal farmers live a life with equality, prosperity and freedom without being exploited.

Basics of Ten Guntha

- Harvest the sunlight falling on the Ten Guntha.
- Need an assured supply of water (1000 L/day).
- Equity sharing with the Labor working in the model.
- Use only neighborhood resources.
- Use of latest science and manifest its outcome.

References

Dabholkar, S.A. (2001). Plenty for All Prayog Pariwar Methodology. Mehta publishing House, Pune, India. 272pp.

Suchade, D. (2011). Natueco farming. Malpani Trust "SHARAN", Bajwada, Nemawar, Khategaon, Dewas, M.P., India. The Trust Handouts.

Volume: 04 Issue No: 12

REGENERATIVE AGRICULTURE: GROWING FOOD, RESTORING ECOSYSTEMS, AND COMBATING CLIMATE CHANGE

Article ID: AG-VO4-I12-84

***Dr.Smriti Singh**

Assistant Professor, School of Agriculture

Sanjeev Agrawal Global Educational University, Bhopal, Madhya Pradesh, India

Corresponding Author Email ID:* smritisingh1199@gmail.com

Introduction

As the world grapples with climate change, biodiversity loss, and soil degradation, there is a growing interest in agricultural practices that can aid in the healing of the land, restoring ecosystems, and producing food sustainably. One of the most promising approaches to achieving this objective is regenerative agriculture. However, it is often criticized. Regenerative agriculture is often confused with organic farming, but it goes beyond simply avoiding synthetic chemicals and focuses on rebuilding soil health, enhancing biodiversity, and increasing carbon sequestration. In this blog, we will explore what regenerative agriculture is, why it is important, and how it works. What is Regenerative Agriculture? Regenerative agriculture is a farming approach that seeks to improve and regenerate the health of the soil, plants, animals, and environment. It is a farming approach that seeks to improve and regenerate the health of the soil, plants, animals, and ecosystem. It encompasses a comprehensive set of methodologies aimed at restoring the land's capacity to function as a living, self-sustaining system. Regenerative agriculture aims to enhance the natural processes of the ecosystem, making farms more resilient and productive over time. The principles of regenerative agriculture are rooted in the notion that healthy soils and diverse ecosystems are fundamental for flourishing food systems. These techniques can be applied to a wide range of farming systems, including crop production, livestock grazing, agroforestry, and even urban farming.

Key Principles of Regenerative Agriculture

1. Soil Health and Carbon Sequestration Soil is the foundation of regenerative agriculture and agriculture. A healthy soil is full of organic material, brimming with life (microbes, fungal species, and insects) and capable of holding more water and nutrients. Cover cropping, composting, minimal tillage, and crop rotation are some of the techniques used to boost soil fertility and structure in regenerative ways. Regenerative agriculture focuses on carbon sequestration as an important aspect. Regenerative farmers can capture carbon from the atmosphere by building soil organic matter and increasing soil biodiversity. This approach not only combats global warming but also boosts the condition of the earth's soil.

2. Diversity and Ecosystem Health Regenerative agriculture helps biodiversity both above and below ground. Diverse ecosystems are more resistant to pests, diseases, and climate extremities. Farmers can encourage biodiversity by using different types of plants, animals, and methods like agroforestry, rotational grazing, and polycultures. This creates a more balanced farm system that is self-regulating. When managed properly, livestock can play an important role in regenerative agriculture. In particular, livestock can play an important role in regenerative agriculture. Cattle, sheep, and goats can help maintain soil fertility and prevent overgrowth. By rotating grazing areas and refraining from overgrazing, farmers enable pastureland to recover and regenerate, thereby enhancing the health of both plants and soil.

3. Water Management Water efficiency is crucial for regenerative agriculture. To make the soil better at holding water, you can use techniques like less tillage and covering crops. This helps prevent drought and reduce the need for irrigation. Water management practices that reduce runoff can prevent soil erosion and protect water quality.

4. Minimizing External Inputs Regenerative agriculture seeks to reduce or eliminate the reliance on external inputs such as synthetic fertilizers, pesticides, and herbicides, in order to achieve this goal. Instead, it employs natural techniques for pest management, nutrient cycling, and soil fertility management. This helps build more resilient farming systems by reducing the environmental impact of farming and helping build more resilient farming systems.

5. Integrated Livestock and Crop Systems The combination of livestock and crops can create a mutually beneficial system. Livestock provide manure that can be composted to make it better. Crop residues can be used to feed animals, creating a circular system that reduces waste while increasing efficiency. Moreover, the utilization of animals can facilitate the management of weeds, pests, and soil aeration.

Benefits of Regenerative Agriculture

1. **Improved Soil Health** Regenerative agriculture helps improve soil health, make soil more fertile, and reduce the need for artificial fertilizers. Soils that are healthier can hold more water, support a wide range of plant life, and foster a healthy ecosystem of beneficial microorganisms.
2. **Carbon Sequestration** Regenerative agriculture can help solve climate change by using carbon sequestration. The soil can hold a lot of carbon, and regenerating it can make it even bigger. This can help reduce the effects of global warming.
3. **Biodiversity Preservation** The diversity of life on farms, from microorganisms to plants and animals, is essential to ecosystem resilience. Regenerative agriculture can improve pest and disease control, increase pollination, and protect endangered species by encouraging biodiversity.
4. **Enhanced Farm Resilience** Farms that practice regenerative agriculture are more resistant to extreme weather events, such as floods, droughts, and heat waves. Healthy soil absorbs more water, which reduce the risk of flooding. Different crop and livestock systems can bounce back more easily after bad weather.
5. **Economic Sustainability** While transitioning to regenerative practices can require initial investment in time, resources, and education, regenerative agriculture can lead to long-term cost savings. By reducing the dependence on costly synthetic chemicals, enhancing soil fertility, and enhancing resilience to weather extremes, farmers can achieve improved profitability over the long haul. Regenerative practices can result in higher-quality products that can be marketed as environmentally sustainable.

Challenges and Considerations

Despite its benefits, regenerative agriculture faces several challenges, among them:

Knowledge and Education: Regenerative agriculture necessitates specialized expertise and a profound comprehension of ecological principles. Training and support is needed by many farmers to adopt these practices effectively.

Transition Period:

Switching from conventional farming techniques to regenerative ones may require a transition period, during which yields may plummet before the soil starts to flourish. Financial help and incentives can help farmers during this time.

Policy and Infrastructure:

The necessary infrastructure, subsidies, and market access are needed for regenerative agriculture to be viable for farmers.

Prospects of Regenerative Agriculture

Climate change, environmental degradation, and global food insecurity can be overcome with regenerative agriculture. As awareness grows, more farmers, consumers, and businesses are adopting regenerative practices, and governments are beginning to see the potential. In the future, we may see more research on regenerative farming, more support for farmers who use regenerative farming, and more people using regenerative practices. Regenerative agriculture could help address the many challenges we face, such as climate change, soil erosion, biodiversity loss, and food security.

As consumers, we can support regenerative agriculture by choosing products from farms committed to regenerative practices. We can do this by choosing products from farms committed to regenerative practices. The shift toward a more sustainable food system that feeds both the land and the people who rely on it can be accelerated by casting our votes.

Conclusion

Regenerative agriculture is not merely a collection of farming techniques; it is a movement that aims to fundamentally alter our relationship with the land. A more sustainable, resilient, and equitable future can be achieved by restoring and regenerating the health of our soils, ecosystems, and communities. As this approach gains momentum, it offers hope that we can restore the planet one farm at a time.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

VERMI COMPOST- A POTENTIAL TECHNOLOGY FOR SUSTAINABLE AGRICULTURE

Article ID: AG-VO4-I12-85

Dr. B. Santhosh* and Dr. S. Ramesh Babu

Assistant Professor (Crop Physiology), Acharya N.G. Ranga Agricultural University

Dr. S. Ramesh Babu, Assistant Professor, Acharya N.G. Ranga Agricultural University

*Corresponding Author Email ID: santoshphysio12@gmail.com

Abstract

Vermi compost is one of the most potential technologies available at farmer level to achieve sustainability. This article discusses the fundamentals of vermin compost preparation and how this organically improves crop productivity as well a soil health. And here the characteristic features of *Eisenia fetida* are discussed. The vermi compost impacting the crop and soil productivity attributes in positive and sustainable way.

Charles Darwin described earthworms as "unheralded soldiers of mankind".

Key words: vermi compost, organic agriculture, sustainable agriculture

Introduction

Vermicomposting is generally defined as the solid phase decomposition of organic residues in the aerobic environment by exploiting the optimum biological activity of earthworms and microorganisms. Vermicomposting is described as "bioxidation and stabilization of organic material involved by the joint action of earthworms and mesophilic micro-organisms". Vermicompost produced by the activity of earthworms is rich in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulase and chitinase and immobilized microflora. The enzymes continue to disintegrate organic matter even after they have been ejected from the worms *(Barik et al., 2011).* Vermicmpost is accepted as humus bio fertilizer, soil fertility booster, soil activator and soil conditioner with required plant nutrients of storage polysaccharides and structural polysaccharides, and beneficial microorganisms like nitrogen fixing, phosphate solubilising, denitrifying, decomposing bacteria and methanogenic bacteria

There are different species of earthworms viz. *Eisenia fetida* (Red earthworm), *Eudrilus eugeniae* (night crawler), *Perionyx excavatus*, *Dendrobaena Veneta* (European night crawler), *Dendrobaena rubida*, *Lumbricus rubellus* etc.

***Eisenia fetida*:**

Named as tiger worm, *Eisenia fetida* is the most common type of earthworm used for vermicomposting. Given its features like

- Rapid rate of growth
- Feed on almost any organic matter
- Easy handling nature
- High reproduction rate
- Wide temperature tolerance
- It is a surface feeder and it converts organic materials into vermicompost from top.

Table1: The favourable conditions for better growth of *Eisenia fetida*

Moisture range	60% - 90%
Temperature tolerance	Up to 35^{o}C
Life cycle	45 to 51 days
Rate of cocoon production	0.4 to 1.3 cocoon day
Incubation period	18 to 26 days
Life expectancy	4.5 to 5 years
Hatching viability	80%
Hatching time for sexual maturity	21 to 30 days
Average survival rate at 18^{o}C to 28^{o}C	20 months

Vermicompost brings about average increases of 26% in commercial yield, 13% in total biomass, 78% in shoot biomass, and 57% in root biomass. In many findings, the positive effect of vermicompost on plant growth reaches a maximum when vermicompost represented 30 to 50% of the soil volume.

Earthworms excreta (vermicast) is a nutritive organic fertilizer rich in humus, NPK, micronutrients, beneficial soil microbes; nitrogen-fixing, phosphate solubilizing bacteria, actinomycets and growth hormones auxins, gibberlins and cytokinins. Both vermicompost and its body liquid (vermiwash) are proven as both growth promoters and protectors for crop plants (Adhikary, 2012).

The high percentage of humic acids in vermicompost contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanin's and flavonoids which may improve the plant quality and act as a deterrent to pests and diseases (Theusnissen *et al*., 2010). vermicompost contains a high proportion of humic substances, which provide numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (Bacillus), yeasts (Sporobolo-myces and Cryptococcus) and fungi (Trichoderma), as well as chemical antagonists such as phenols and amino acids (Theunissen *et al*., 2010)

Earthworms and vermicompost can boost horticultural production without agrochemicals. It will provide several social, economic and environmental benefits to the society by way of producing 'chemical-free' safe, 'nutritive and health protective' (rich in minerals and antioxidants) foods (even against some forms of cancers) for the people; salvaging human wastes and replacing the dangerous 'agrochemicals' from the face of earth. The use of vermicompost in farms also 'sequester' huge amounts of atmospheric carbon (assimilated by green plants during photosynthesis) and bury them back into the soil improving the soil fertility, preventing erosion or compaction and also reducing greenhouse gas and mitigating global warming (Sinha *et al*., 2013).

Vermicompost is ideal organic manure for better growth and yield of many plants due to following reasons (Joshi *et al*., 2015):

1. Vermicompost has higher nutritional value than traditional composts.
2. This is due to increased rate of mineralization and degree of humification by the action of earthworms.
3. Vermicompost has high porosity, aeration, drainage, and water-holding capacity.
4. Presence of micro biota particularly fungi, bacteria and actinomycetes makes it suitable for plant growth. Nutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost.

5. Plant growth regulators and other plant growth influencing materials produced by microorganisms are also present in vermicompost.

6. Production of cytokinins and auxins was found in organic wastes that were processed by earthworms.

7. Earthworms release certain metabolites, such as vitamin B, vitamin D and similar substances into the soil.

8. In addition to increased N availability, P, K, Ca and Mg availability in the casts are found.

Vermi compost stimulates the emergence of plants because of the presence of major nutrients and other essential nutrients like P and K.

Effect on plant

Growth and development of plants is due to the presence of humic acids micronutrients and macronutrients in vermicompost.

Effect on roots

Hormone like activity of vermicompost leads to an increase in root biomass, root initiation and better growth and development of plants.

Effect on leaves and chlorophyll

Plant-available form of nitrogen (nitrate) is greater in vermicompost. Available N is greater in vermicompost than conventionally composted manure. N fertilization increased growth and leaf area index of plant which in turn increases absorption of light leading to more dry matter and yield.

Effect on flowering

Increase in N levels, microbial activity on adding vermicompost to greater root expansion, which in turn leads to greater uptake of nutrients, water and rate of photosynthesis, ultimately leading to better flowering and heading (Taleshi *et al*. 2011).

Effect on fruiting

Plants receiving vermicompost might have received nutrition in a balanced and sustained way than those receiving inorganic fertilizers it might have helped the plants in producing albino and malformed fruits in lesser number (Singh *et al*. 2008).

Effect on ion uptake

The vermicompost introduce the microorganisms in rhizosphere of plants, which leads to more availability of N and K by biological fixation of nitrogen and biological solubilization of P.

Table 2: Chemical composition of vermicompost (Garg, Gupta 2009)

characteristics	values
Organic carbon, %	9.15-17.88
Total nitrogen, %	0.5-0.9
Phosphorous, %	0.1-0.26
Potassium, %	0.15-0.256
Sodium %	0.055-0.3
Calcium and magnesium(Meq/100g)	22.67-47.6
Copper, mg/kg	2.0-9.5
Iron, mg/kg	2.0-9.3
Zinc, mg/kg	5.7-9.3
Sulphur, mg/kg	128.0-548.0

Conclusion

The vermi compost is justified organic manure that can be produced out of widely available farm and kitchen waste and earth worms. vermicompost can enhance soil fertility physically, chemically and biologically. Physically, vermicompost-treated soil has better aeration, porosity, bulk density and water retention. Chemical properties such as pH, electrical conductivity and organic matter content are also improved for better crop yield. It boosts the nutrients available to plants, helping seeds to germinate more quickly, grow faster, develop better root systems and produce higher yields. That means more flowers or fresh fruits and vegetables.

References

Adhikary, S. 2012. Vermicompost, the story of organic gold: A review. Agricultural Science. 3:905–917.

Barik, T., Gulati, J.M.L., Garnayak, L.M, Bastia, D.K. 2011. Production of vermicompost from agricultural wastes. – Agricultural Reviews, 31(3):172–183.

Joshi, R., Singh, J., Vig, A.P. 2015. Vermicompost as an effective organic fertilizer and biocontrol agent:effect on growth, yield and quality of plants. – Rev in Environmental Sciences and Biotechnology. 14(1):137–159.

Singh R, Sharma RR, Kumar S, Gupta RK, Patil RT: Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (Fragaria x ananassa Duch.). *Bioresour Technol* 2008, 99: 8507–8511.

Sinha, R.K., Hahn, G., Soni, B.K., Agarwal, S. 2014a. Sustainable Agriculture by Vermiculture. International Journal of Agricultural Research Review., 2(8):99–114.

Taleshi K, shokoh-far A, Rafiee M, Noormahamadi G, Sakinejhad T: Effect of vermicompost and nitrogen levels on yield and yield component of safflower (*Carthamus tinctorius* L.) Under late season drought stress. *International journal of Agronomy and Plant Production* 2011,2(1):15–22.

Theunissen, J., Ndakidemi, P.A., Laubscher, C.P. 2010. Potential of vermicompost produced from plant waste on the growth and nutrient status in vegetable production. – International Journal of Physical Sciences. 5(13):1964–1973.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

GANODERMA: THE "MUSHROOM OF IMMORTALITY"

Article ID: AG-VO4-I12-86

Vignesh K[1] and Arsha G [2]

[1,2]Assistant Professor (Plant Pathology), Department of crop protection,

Palar Agricultural College, Vellore – 635 805, Tamil Nadu, India

*Corresponding Author Email ID: vigneshpatho97@gmail.com

Introduction

Ganoderma is a genus of fungi that has been revered for centuries in traditional medicine, particularly in East Asia, for its potential health benefits. Known as the "mushroom of immortality," this medicinal fungus is a part of the *Ganodermataceae* family and is most commonly found on decaying wood in tropical and subtropical forests.

Types of *Ganoderma*

The genus *Ganoderma* includes several species, but the most well-known and researched is *Ganoderma lucidum*, also called Reishi or Lingzhi. *Ganoderma lucidum* has a glossy, reddish-brown appearance with a hard, woody texture, which has earned it the nickname "king of herbs."

Historical Significance

Ganoderma has a long history in traditional Chinese, Japanese, and Korean medicine. Ancient texts describe it as a powerful tonic, believed to promote longevity, vitality, and general well-being. In Chinese culture, it was once reserved for royalty and nobility due to its rarity and potent healing properties. In these traditions, it is thought that *Ganoderma* can help balance the body's “Qi” (vital energy), promote harmony, and boost the immune system. It has also been used to treat a wide range of ailments, including chronic fatigue, anxiety, high blood pressure, and respiratory disorders.

Active Compounds

The health benefits attributed to *Ganoderma* are primarily due to its bioactive compounds, which include:

Triterpenoids: These compounds are thought to possess anti-inflammatory, anti-tumor, and liver-protective properties. They also contribute to the bitter taste of the mushroom and are one of the main components responsible for its medicinal effects.

Polysaccharides: Particularly beta-glucans, these are known for their immune-modulating properties. Polysaccharides stimulate the immune system, helping to increase the body's resistance to infections and potentially aiding in cancer therapy.

Peptides and Proteins: These compounds may assist in regulating blood sugar levels, protecting the liver, and enhancing the body's ability to detoxify.

Sterols and Organic Acids: *Ganoderma* also contains compounds like ergosterol, which may have antioxidant and anti-inflammatory effects, as well as the potential to support overall metabolic health.

Health Benefits

Immune System Support: One of the most well-known benefits of *Ganoderma* is its ability to strengthen the immune system. The polysaccharides in *Ganoderma* have been shown to stimulate the production of white blood cells, which are crucial for defending the body against infections and diseases.

Anti-cancer Properties: Research suggests that *Ganoderma* may help inhibit the growth of cancer cells and support conventional cancer treatments. Some studies indicate that the triterpenoids and polysaccharides found in *Ganoderma* can slow down the progression of cancer by promoting apoptosis (programmed cell death) in malignant cells.

Anti-inflammatory Effects: Chronic inflammation is linked to many health problems, including heart disease, arthritis, and diabetes. *Ganoderma* has demonstrated the ability to reduce inflammatory markers in the body, potentially alleviating the symptoms of these conditions.

Cardiovascular Health: Some studies indicate that *Ganoderma* may help lower blood pressure, reduce cholesterol levels, and prevent the buildup of plaque in the arteries, thus supporting cardiovascular health.

Liver Protection: *Ganoderma* has been traditionally used to support liver function and detoxification. Research suggests it can protect against liver damage caused by toxins and may help in the regeneration of liver cells.

Stress Reduction and Mental Clarity: Known for its adaptogenic properties, *Ganoderma* is believed to help the body cope with stress by regulating the endocrine system and promoting a calm, balanced state of mind. It is also thought to improve cognitive function, mental clarity, and overall mood.

Usage and Forms

Ganoderma is typically consumed in the form of powdered extract, capsules, or tea. The dried fruiting body of the mushroom is often used to create extracts that contain concentrated amounts of the beneficial compounds. *Ganoderma* tea has become popular for its mild, earthy taste and potential health-promoting properties.

While *Ganoderma* is considered safe for most people, it's important to consult with a healthcare provider before using it, especially if you're pregnant, breastfeeding, or taking medications. Some individuals may experience mild side effects, such as digestive upset or allergic reactions.

Modern Research and Future Potential

Today, *Ganoderma* is the subject of ongoing scientific research. Studies have explored its potential in treating cancer, boosting immunity, and even supporting metabolic health. Though much of the research is still in its early stages, the growing body of evidence suggests that *Ganoderma* could have a wide range of therapeutic applications.

However, it's worth noting that many of the claims surrounding *Ganoderma*'s health benefits are based on traditional knowledge and anecdotal evidence, and more rigorous, large-scale clinical trials are necessary to fully understand its potential.

Conclusion

Ganoderma, or Reishi mushroom, is one of the most well-regarded medicinal fungi, with a long history of use in traditional medicine. Its active compounds, particularly triterpenoids and polysaccharides, contribute to its numerous health benefits, from immune system enhancement to potential anti-cancer effects. While modern research is still catching up with ancient wisdom, *Ganoderma* remains an exciting subject of study and a popular natural supplement for those looking to improve their overall health and well-being.

References

Cheng, S. (2014). *Ganoderma*: The Mushroom of Immortality in Traditional Chinese Medicine. *Journal of Asian Medicine*, 10(2), 45–55.

Healthline. Reishi Mushroom Benefits, Uses, and Risks: https://www.healthline.com/nutrition/reishi-mushroom

Hobbs, C. (2000). *Medicinal Mushrooms: An Exploration of Tradition, Healing, & Culture*. Botanica Press.

Memorial Sloan Kettering Cancer Center. *Ganoderma lucidum*: https://www.mskcc.org/cancer-care/integrative-medicine/herbs/ganoderma-lucidum

National Center for Biotechnology Information (NCBI). Articles on *Ganoderma lucidum*: https://www.ncbi.nlm.nih.gov

Paterson, R. R. M. (2006). *Ganoderma* – A therapeutic fungal biofactory. *Phytochemistry*, 67(18), 1985–2001. DOI:10.1016/j.phytochem.2006.07.004

Wachtel-Galor, S., & Benzie, I. F. (2011). *Ganoderma lucidum* (Lingzhi or Reishi). In *Herbal Medicine: Biomolecular and Clinical Aspects* (2nd ed.). CRC Press.

Wasser, S. P. (2005). Reishi or Ling Zhi (*Ganoderma lucidum*). *International Journal of Medicinal Mushrooms*, 7(1), 31–42. DOI:10.1615/IntJMedMushr.v7.i1.40

WebMD. Ganoderma Uses and Benefits: https://www.webmd.com

Zhao, J., Zhang, X., & Dong, X. (2013). The Chinese Pharmacopoeia on *Ganoderma*. In *Advances in Medicinal Mushrooms* (pp. 109–128). Springer.

Volume: 04 Issue No: 12

GREEN AQUACULTURE: ALTERNATIVE PLANT BASED PROTEIN SOURCES FOR FISH FEEDS

Article ID: AG-VO4-I12-87

[1]Bhavy A. Dalsaniya, [2]Dr. Ravindragouda Patil and [3]Shivani D. Gowda

[1, 3]Department of Aquaculture, College of Fisheries, KVAFSU, Mangaluru, Karnataka, India

[2]Assistant Professor, ICAR- Krishi Vigyan Kendra, KVAFSU, Mangaluru Karnataka, India

*Corresponding Author Email ID: dalsaniyabhavy9918@gmail.com

Introduction

The need to identify alternative protein sources is driven by the rising costs and ecological concerns associated with traditional fishmeal production. Aquaculture production is rapidly expanding, and the sustainability of this growth depends largely on the feed sector, which currently relies heavily on fishmeal. The depletion of wild fish stocks, increased regulations on fishing, and high volatility in fishmeal prices have highlighted the need for sustainable alternatives. Plant-based protein sources offer a promising solution, but they must be carefully assessed to ensure they provide a comprehensive nutrient profile and do not negatively impact the health and growth performance of fish species.

FISH MEAL AS A BASIC FEED INGREDIENT

Fishmeal (FM) is one of primary sources of protein used in aquaculture feeds due to the following characteristics available in fish meal.

- It’s high-quality protein content,
- Balanced amino acid profile, and
- Rich nutrient availability.

However, with growing concerns around **sustainability**, overfishing, and the **high costs** of fishmeal, there is an urgent need to explore alternative protein sources for aquaculture. Among the various alternatives, **plant-based protein** sources have emerged as a promising solution, but they also come with challenges such as anti-nutritional factors (ANFs), low digestibility, and unbalanced amino acid profiles.

NEED FOR ALTERNATIVE OPTION OF FISH MEAL

Fishmeal has historically been a cornerstone of aquafeeds due to its superior nutritional qualities, but its production is no longer economically and environmentally sustainable. Fishmeal is derived from small, oily fish species, many of which are subject to overfishing. Furthermore, aquaculture's rapid growth is increasing the demand for fishmeal at a rate that natural fisheries cannot sustain. This has led to fishmeal prices tripling over the past decade, making it a costly feed ingredient. Replacing fishmeal with plant-based proteins not only reduces pressure on marine ecosystems but also offers a more cost-effective approach for feed manufacturers.

PROMINENT PLANT-BASED PROTEIN SOURCES

1. SOYBEAN MEAL:

Soybean meal is one of the most widely used plant-based protein sources in aquafeeds due to its high protein content (around **44-48%**) and balanced amino acid profile. However, its use is limited by the presence of anti-nutritional factors such as trypsin inhibitors, lectins, and oligosaccharides. Soybean meal is typically processed through heat treatment or fermentation to reduce these compounds. Soybean protein concentrate (SPC) and fermented soybean meal (FSM) are advanced forms with reduced ANFs and improved digestibility, making them more suitable for high inclusion levels in fish diets.

Fermented soybean meal (FSM) is produced by introducing certain microorganisms into SBM for a fixed time period for fermentation by which ANFs are broken down and specific bioactive substances such as short peptides, probiotics, flavonoids, and organic acids are produced that improve the growth and health of aquatic animals. Mostly, the solid state fermentation process is utilized to produce FSM that includes the grinding, steam sterilizing and adding of microorganisms for fermentation for a fixed period. Fungi and bacteria that are mostly used are *Lactobacillus*, *Aspergillus*, *Bacillus*, *Saccharomyces*, etc. Fermentation process, strains composition, and conditions show great impact on the FSM quality. FSM significantly ($p<0.05$) improved the growth, intestinal morphology and increased disease resistance of south American catfish, crucian carp and largemouth bass, respectively.

2. COTTONSEED MEAL

Cottonseed meal has a protein content of about 41% and is a good source of fiber. However, its application is limited by the presence of gossypol, a toxic compound that can reduce fish growth and health when consumed in high quantities. To overcome this, the cottonseed meal is processed to create cottonseed protein concentrate (CPC), significantly lower levels of gossypol. Techniques like solvent extraction and fermentation have shown promise in improving its safety and nutritional value.

3. CORN GLUTEN MEAL

Corn gluten meal is a by-product of the corn milling industry, known for its high protein content. It is beneficial plant protein source due to local availability, high protein content that is 60–70% of dry matter, low fiber content, and specifically due to low cost. The deficiency of EAAs i.e. lysine and arginine and non-soluble carbohydrates i.e. raw starch up to 20% limit its inclusion in fish feed. These non-soluble carbohydrates are reduced by enzymatic treatment and converted to corn protein concentrate (CPC) with high protein parts. Despite this, corn gluten meal is widely used due to its digestibility and affordability, particularly in diets for omnivorous species like tilapia.

4. RAPSEED MEAL

Rapeseed meal (RSM) is a protein-rich by-product of canola oil production, with a protein content ranging from 35-45%. It is high in sulfur-containing amino acids but lacks lysine, making it necessary to blend with other protein sources. RSM has a large number of ANFs i.e. tannins, phytic acid, sinnapine, erucic acid, glucosinolates and indigestible carbohydrates. RSM also contains glucosinolates, which can impair thyroid function if consumed in large amounts. RSM yield has increased greatly becoming the second most important and commonly used protein source after SBM.

For example Sallam *et al.*, found that RSM, when fed to Nile tilapia and mango tilapia, showed improved weight gain and specific growth rate at 10% inclusion level while RPC replaces 33% of FM.

5. CANOLA MEAL

Canola meal (CM) is the solid matter left after the processing of canola seeds to extract oil containing 40% protein (dry matter) with easy availability and low cost. It also contains ANFs i.e. non digestible oligosaccharides, glucosinolates and phytic acid, that limit its use in fish feed and also increase in gut viscosity and decrease in nutrient assimilation.

Different techniques are used to lower or vanish ANFs that include alkaline and acid treatments, thermal extrusion, enzymatic process, microbial fermentation, and tail end dehulling. All these methods are observed to decrease ANFs, but the benefits are restricted due to net protein loss, high processing cost, and/or partial reduction of ANFs. CM nutritional composition is greatly enhanced by fermentation using microbes to decrease ANFs [64] (Table 5) but due to high simple carbohydrate levels in CM, fermentation effect is limited to complex sugars. The removal of simple sugars by washing CM prior to fermentation increase microbial effect on complex carbohydrates i.e. fiber.

6. PEANUT MEAL

The peanut belonging to the legume family has high oil and protein content with high palatability as compared to other plant protein sources. The extracted peanut oil is used by humans and leftover peanut meal (PM) is rich in protein (55.94 %) and amino acid arginine (6.15%). It also has ANFs, i.e. trypsin, tannins, and amylase inhibitors, that show adverse impacts on fish health. Peanut cake, obtained from oil extraction process by squeezing oil, has great nutritional value specifically rich protein content in range of 410–450 g/kg (dry matter) but imbalance amino acid content.

7. GUAR MEAL

Guar, Cyamopsis tetragonoloba, from family Fabaceae, is a leguminous plant commonly called cluster bean. It is low emission summer crop and used in feed of farm animals. It occurs commonly in the East and South East of Pakistan and North and North West of India. Guar meal is comparatively cheap high protein product gained after guar gum extraction that is valuable for producers of livestock.

Major ANF present is Galactomannan which is D-mannose polymer linked to D-galactose via α-1, 4 linkages attached to alternate β-1, 6 mannose units. The lowest crude protein present is 50% in guar meal in comparison with SBM which has 48% crude protein. Guar meal contains tryptophan 0.68%, methionine 0.73%, cystine 0.79%, meth + cystine 1.51%, threonine 1.94%, isoleucine 2.31%, valine 2.35% lysine 3.22%, arginine 3.62%, and leucine 3.7%. Guar meal is also free from aflatoxin, Salmonella, and E. coli as well as a good binding agent in feed formation. It contains about 1.3 g per kg of saponin content. Guar gum is largely utilized as thickener, stabilizer, and emulsifier in oil and food industries.

8. SUNFLOWER MEAL

Sunflower commonly called “Sooraj Mukhi” is fourth largest crop cultivated globally and contributes up to 30% of gross domestic production of cooking oil. It has 36–40% of crude protein with high tryptophan and methionine content. Main factors that restrict SFM use in fish feed are arginase and protease inhibitors, high fiber content and high phenolic compounds mainly caffeic and chlorogenic acids that also reduce solubility of protein.

9. *MORINGA OLEIFERA* MEAL

Moringa oleifera, from family Moringaceae is a slender tree having softwood. Typically, it is a multipurpose plant having several use in livestock, agriculture, pharmaceutics, human and other biological systems. Moringa fat free kernel and raw kernel meals contain 61.4% and 36.7% crude protein, respectively while in leaves crude protein is 23–30% and crude fiber is less than 5.9%, resulting its good palatability for livestock and fish.

There are ten EAAs present in *M. oleifera* including lysine, histidine, leucine, isoleucine, valine, methionine, phenylalanine, tyrosine, tryptophan, and threonine. These ANFs also give bitter taste resulting in low acceptability to aquatic animals.

10. ALMOND MEAL

Terminalia catappa, from family Combretacea, is commonly known as wild almond, sea almond, Indian almond or tropical almond. They have 24.5% crude protein, 6% ash, 36% crude protein and rich in vitamin E as well as phenolic compounds. Owing to unique antioxidant effects, almond meal boosts immune system, making it effective substitute for FM. Up to 40% almond meal based diet significantly improved the growth performance, nutrient absorption and hematology of *L. rohita.* Although it controls fungal, parasitic and bacterial infections, it also works as a behavioral stimulator for spawning substrate and reproduction.

11. BLACK CUMIN SEED MEAL

Therapeutic effects of black seeds have been recorded as anticancer, antihistaminic, antidiabetic, antioxidant, antiviral, antifungal, antiprotozoal, antibacterial, anticholesterol, anti-inflammatory and immonomodulator. Black seed comprise of crude protein 20.8%, lipids 34.8%, ash 3.7%, carbohydrate 33.7% and 7.0% moisture.

As a whole, owing to local availability, low price, and effectiveness, the use of N. sativa and its oil in aquaculture has been urged as a feed ingredient for better fish health, making them more resistant to bacterial infections such as *Burkholderia cepacian* and *Aeromonas hydrophila*. Most of its pharmacological characters are because of thymoquinone (18.4–24.0%) that is main bioactive element of its volatile oil (0.4–2.5% of seed oil).

12. LUPIN MEAL

Lupin seed meals (LSMs) are included as supplement globally in livestock feed formulation due to its good nutritious value and potential to grow on infertile lands. LSM has good protein content, high dietary fiber and locally available at low price. Comparatively, they have low ANFs including tannins, phytic acid, oligosaccharides and alkaloids than present in other plant based ingredients.

Pretreatment of lupin with Lactobacilli enhanced its nutritional value as well as micronizatin process increased starch digestibility and destroyed the ANFs. Lupin meal can be used in rainbow trout up to 30% without adverse effects on growth performance, hematological and serum biochemical markers.

References

Hussain, S.M., Bano, A.A., Ali, S., Rizwan, M., Adrees, M., Zahoor, A.F., Sarker, P.K., Hussain, M., Arsalan, M.Z.U.H., Yong, J.W.H. and Naeem, A., 2024. Substitution of fishmeal: Highlights of potential plant protein sources for aquaculture sustainability. *Heliyon*.

Daniel, N., 2018. A review on replacing fish meal in aqua feeds using plant protein sources. *Int. j. fish. aquat. Stud.*, **6**(2):164-179.

Aragão, C., Gonçalves, A.T., Costas, B., Azeredo, R., Xavier, M.J. and Engrola, S., 2022. Alternative proteins for fish diets: Implications beyond growth. *Animals*, **12**(9): 1211.

Francis, G., Makkar, H.P. and Becker, K., 2001. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. *Aquaculture*, **199**(3-4):197-227.

Krishnankutty, N., 2005. Plant proteins in fish feed: An additional analysis. *Curr. Sci.*, **89**(6):934-936.

Volume: 04 Issue No: 12

RECYCLING OF ORGANIC WASTES FOR SUSTAINABLE SOIL HEALTH AND CROP GROWTH

Article ID: AG-VO4-I12-88

. Karthikeyan[1*] and T. Selvakumar[2]

[1]Associate Professor (Agronomy), Directorate of Crop Management, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

[2]Associate Professor (Agronomy), Maize Research Station, Tamil Nadu Agricultural University, Vagarai, Tamil Nadu

*Corresponding Author Email ID: agrikarthialr@gmail.com

Abstract

Agriculture and its allied activities generates a variety of wastes including crop residues, wastes from unutilised plants and weeds, animal wastes and byproducts of agro industries. Thus accumulated wastes are dumped along the field sides, producing unpleasant odour and pose problems of their disposal. However, these agricultural wastes are rich source of nutrients which could be effectively recycled to tap the potential of nutrient supply. Most of the agricultural wastes possess no hazardous effect on soil health and also crop growth. The technology of organic wastes recycling has become more essential for replenishing the nutrients supply, sustaining the soil health, besides reducing the environmental pollution and creating employment opportunities. At the present scenario of sustainable crop production, revitalising and restoring the soil fertility and enhancing the crop productivity could be achieved through the strategy of organic wastes recycling.

Keywords: Organic wastes, recycling methods, green manuring, composting, vermicomposting,

Introduction

Agriculture sector plays a vital role in the overall economy of our country. Besides a key producer of food grains for the overwhelming population, it is also a large generator of wastes as wide range of crops are being cultivated across varied agro climatic regions, Cultivation of agricultural crops like cereals and millets, pulses, oilseeds, fibre crops, sugarcane *etc.* produce considerable quantity of their uneconomical plant parts (residues) as wastes. It is estimated that our country generates more than 350 mt of agricultural wastes annually (Kimothi *et al.*, 2020). Apart from these wastes, animal wastes and byproducts like dung, urine, bones *etc.* are also available in adequate quantities which serve as a rich source of energy and nutrient elements. To some extent, the wastes are used in agriculture and other allied industries as animal feed, bedding materials, fuel, organic manures, energy generation, *etc*., while more than 30 per cent of the wastes generated from agriculture in India remain as surplus which possess high economic value.

Organic wastes (also called as agro-wastes) are organic materials of plant and animal origin. Considering their bulkiness and availability in larger quantities, either dumping of the wastes in unutilised lands or incineration through burning is practically impossible as it pose a negative impact on the agro-ecosystem. Such agro-wastes (which are organic in nature) can be effectively utilised in the agriculture production system as they help to improve soil conditions, crop productivity and environmental sustainability. However, application of the raw wastes directly in the land is inappropriate because of their unknown composition of the nutrients content, toxic substances, pathogens, presence of weed seeds, *etc.* Therefore, application of the wastes in the land after their recycling into valuable and nutrient rich materials is considered to be an attractive and cost effective technology. Considering the growing deficiency of plant nutrients in crop field, higher cost of synthetic fertilizers and poor efficiency of chemical fertilizers, the organic wastes recycling for plant nutrient supply is becoming more essential for replenishment of plant nutrients, sustaining soil health, reducing the pollution problem and creating employment opportunities, which is now being increasingly recognized as a strategy for sustainable crop production. These wastes have proved to supply plant nutrients and organic matter for crop production. Thus recycling of agro-wastes becomes a subject not only of agro-ecological concern, but also connected with improved soil and plant health. The role of recycled organic wastes on nutrient supply, improvement of soil biophysical properties, soil organic matter and crop yields are well documented (Amundson *et al*. 2015; Chatterjee *et al.,* 2017).

Classification of organic wastes

Organic wastes in agriculture can be classified into

- Wastes from agricultural activities (Crop wastes/ weed biomass)
- Animal wastes/ byproducts
- Other wastes (Agro-industrial wastes/ byproducts)

The type of organic wastes and their sources available for recycling into valuable products are mentioned in Table 1.

Table 1. Organic wastes and their sources

Group	Types of wastes	Sources of wastes
Plant wastes	Crop residues	Field crop residues and biomass
	Kitchen wastes	Daily kitchen wastes
	Green market wastes	Fruits and vegetable market wastes
	Coconut/ arecanut/ perennial wastes	By-products of these crops
	Forest biomass	Natural forest biomass and by-products
	Road side vegetation	Weeds and invasive plants biomass
	Aquatic plant biomass	Biomass of aquatic plants
Animal wastes	Animal dung and urine	Faeces and urine of domestic animals and dairies
	Poultry excreta	Poultry droppings of broiler and layering farms
	Fish meal and fish wastes	Wastes from fresh and sea water fish industries
	Biogas slurry	By-product of biogas plant
Other wastes	Sugar industry and distillery wastes	Spent and effluent of sugar industry
	Paper mill industrial wastes	Spent and effluent of papermills
	Fly ash	Generated from thermal power plants

Source: Chatterjee *et al.* (2017)

1. *Wastes from agricultural activities*

a. *Crop residues/wastes*

The major quantity of organic wastes from agricultural sources include crop residues of cereals, pulses, oilseeds (rice, wheat, jowar, bajra, greengram, blackgram, cowpea, pigeonpea, groundnut, linseed, other crops), stalks of maize, cotton, jute, tapioca leaves, other wastes like rice husk, saw dust, tea waste, coconut husk, sugarcane tops, bagasse, jute fibre, wastes from vegetables *etc*. These wastes are rich in carbohydrates, proteins, lipids, waxes and pigments. The proportion of those components differ with the age of plants, rate of decomposition and with the

C:N, C:P and C:S ratios. These wastes do not act as a source of nutrients directly. However, on decomposition (through physico-chemical and microbiological processes), they release nutrients that are utilised by the plants.

With a production of 113.3 mt of wheat, 137.8 mt of rice, 37.6 mt of maize, 56.9 mt of millets, 453.2 mt of sugarcane, 43.1 mt of fibre crops (jute, mesta, cotton), 24.2 mt of pulses and 39.6 mt of oilseeds crops in the year 2023-24 (MoA & FW, 2024), it is evident that a huge volume of crop residues are produced both on-farm and off-farm. It is estimated that about 400-450 mt of crop residues are produced per year in the country. However, a large portion of the residues is burnt on-farm primarily to clear the field for sowing of the succeeding crop. The problem of on-farm burning of crop residues is intensifying in recent years due to shortage of human labour, high cost of removing the crop residues by conventional methods and use of combines for harvesting of crops. Such huge quantity of surplus crop residues could be effectively recycled for their multi-uses as compost, biofuel, biochar, as livestock feed, mushroom cultivation, as surface mulch *etc.*

b. Biomass of weeds

Weeds compete with crops for nutrients, water and light thereby reducing the crops yield. Apart from causing yield reduction, they also pose health hazards and also responsible for the loss of biodiversity. Though weeds cause considerable damage in various ways, they are not regarded as absolutely useless and many advantages have been attributed to them. In order to maintain ecological balance, it is necessary to utilize the weed biomass generated in and around our ecosystem very effectively. Utilization of these weed biomass for various purposes certainly give a better substitution of the certain resources, which are under scarcity, so that better conservation of resources will be meet in long run. Several weeds are used for green manuring and composting, (*e.g. Ipomoea carnea, Eichhornia crassipes, Vernonia, Calotropis gigantia, Cassia tora*), as soil additives, mulch, fertilizer, pulp and fibre for paper making, animal feed and for biogas production and in silkworm rearing.

One of the most promising methods to utilize the weeds is to use them to make compost. They also generally contain adequate nutrients (C/N ratio is between 20 to 30), which favour the growth of microbes that produce compost. The compost nitrogen is in both organic (or cell biomass) and inorganic forms and is released into the soil gradually, and is thus available throughout the growing season.

2. Animal wastes

Animal wastes are major sources of greenhouse gas, pollution, pathogens and odour. 40 % of global methane is produced by agriculture and livestock by-products followed by 18 % from waste disposal globally. Traditionally the dung cakes are utilized for cooking the food in rural areas. The increasing use of petroleum products forced us to utilize the ability of livestock waste for various possible energy products; among them biogas is most popular product in major countries of the world. Good quality organic fertilizer from animal waste provides an opportunity for the agricultural sector to reduce their reliance on chemical fertilizer which improves the soil fertility and sustainability. Proper utilization of cow dung and cow urine into manure, pesticides, medicines and other daily products can generate millions of employment opportunities in rural areas as well it can protect soil from chemicals and fertilizers and improve soil fertility.

3. Other wastes (agro-industrial wastes)

Today, organic wastes from agro-industries are one the major sources of pollution. Industries generate organic wastes, which include the by-products of the agri food industry such as coffee dregs, bagasse, degummed fruits and legumes, milk serum, sludge from wool, cellulose, etc. Such organic wastes are increasing day by day and considered to have harmful effects on the environment. Proper and effective waste management must be performed without creating risks to the natural resources such as water, air, soil, or the flora and fauna. To reduce such agro-industrial pollution, clean technology has to be implemented through recycling.

Recycling of organic wastes

Recycling of organic wastes can be most effectively accomplished by biological processes, employing the activities of microorganisms such as bacteria, algae, fungi, and other higher life forms. The byproducts of these biological processes include compost fertilizer, biofuels, and protein biomass. As the growth of organisms (or the efficiency of organic waste treatment/recycling) is temperature dependent, areas having hot climates are the most favourable for waste recycling than temperate-zones. The technologies of waste recycling should be simple, practical, and economical for use, and they should both safeguard public health and reduce environmental pollution.

Factors affecting recycling of organic wastes

1. Availability of organic wastes based on the type of crop, alternate use pattern, crop agronomic practices, soil type, nutrient composition of the wastes, purity, mineralisation

capacity of the wastes *etc.*

2. Quality of organic wastes - decided by the dry matter content, presence of toxic substances, presence of disease inoculums, weed seeds
3. Technical know-how – for proper method of composting, maintenance of moisture level, methods to reduce nutrient leaching, cost involved in composting, *etc.*
4. Social factors - like regular demand for alternate use and easy availability of chemical fertilizers at subsidised rate and reluctance among the users towards usage of recycled wastes also influence the wastes recycling process.

Methods of recycling of organic wastes

1. ***In- situ recycling: raising of green manuring crop***

Cultivation of green manure or green leaf manure crops help to improve soil structure, increase in water holding capacity and decreased soil loss by erosion. It reduces weed proliferation and weed growth. Besides it also helps in reclamation of alkaline soils and minimise the attack of root knot nematodes. Green manures are a valuable potential source of nitrogen and organic matter. In rice-based cropping systems dhiancha (*Sesbania sp*.) is highly suitable as green manure crop for water logging and heavy rain fall areas whereas sunnhemp (*Crotalaria juncea*) is suitable for rainfed areas. Greengram, blackgram, fodder cowpea, horsegram are preferred green manure crops for tropical climate. A 45- to 60-day-old green manure crop can generally accumulate about 100 kg N/ha, which corresponds to the amount of mineral fertilizer nitrogen applied to crops. Sometimes green manure crops accumulate more than 200 kg N/ha. Integrated use of green manure and chemical fertilizer can save 50 - 75% of the required nitrogen fertilizers in rice. Green manuring also increases the availability of several other plant nutrients through its favourable effect on chemical, physical and biological properties of soil.

2. ***Mulching of organic residues***

Covering of root rhizosphere with mulch materials helps in suppressing weed growth, improving water infiltration, increasing soil water retention, maintaining the surface soil structure, drought tolerance and also protecting it from erosion and the leaching of nutrients. Biomulch accelerated the decomposition of crop residue and enhance nutrient cycling. It works by encouraging the natural bio-degradation process. Application of bio-mulches can improve the soil organic matter content, the water and nutrient retention in soils susceptible to leaching and stabilize soil pH. It can be a good source of both macro and micro nutrients. However, these benefits can be reduced in hot humid climates, in which the decomposition of organic matter is faster than in temperate climates. For annual crops the bio-mulches should be applied during sowing of the crops and for perennial crops it can be applied during the growing stages of the crop. Sufficient residual moisture should be maintained for proper decomposition and release of nutrients.

3. *Composting*

Composting is the process of bio-conversion of organic wastes into an amorphous dark brown to black colloidal humus like substance under conditions of optimum temperature, moisture and aeration. It is an economically attractive technique of organic waste disposal and recovery of valuable plant nutrients. Generally, composting is applied to solid and semi-solid organic wastes such as night soil, sludge, animal manures, agricultural residues and municipal refuse, whose solid contents are usually higher than 5 %. As composting process can release more heat energy resulting in a rapid decomposition rate, aerobic composting has been a preferred technology for stabilizing large quantities of organic wastes. Anaerobic composting is a slow process and can produce obnoxious odours originating from the intermediate metabolites like mercaptans and sulfides. The are several methods of composting of organic wastes which include Indore method, chimney method, Coimbatore method, Japanese method and Vishista method.

4. *Vermicomposting*

Vermicompost is an organic cast obtained from the ingested biomass by earthworm. During ingestion, the earthworms fragment the wastes substrate, accelerate the rates of decomposition of the organic matter and alter the chemical and physical properties of the material. It is rich in in nitrogen, phosphorus and potassium as well as humic acids, plant growth promoting substances like auxins, gibberellins and cytokinins, N-fixing and phosphate solubilizing bacteria, vitamins, antibiotics, enzymes *etc*.

5. *Biofuels production*

Biogas (also called 'marsh gas'), a by-product of anaerobic decomposition of organic matters has been considered as an alternative source of energy. The biogas can be used at small family units for cooking, heating and lighting, and at larger institutions for heating or power generation. The common raw materials used for biogas generation are animal manure, sewage sludge and vegetable crop residues, all of which are rich in nutrients suitable for the growth of anaerobic bacteria. Its production typically varies from 0.8 to 1.6 m^3 per adult unit per day. From 1 ton of manure with 20 % solid content, 20–25 cubic meter biogas can be produced with a total energy value of 100–125 kWh and the same can be utilized to generate 35–40 kWh of electricity and 55–75 kWh of heat energy. The slurry or effluent from biogas digesters, is rich in nutrients and is a valuable fertilizer. It contains about 1.8% N, 1.10 % P_2O_5 and 1.50% K_2O. The normal practice is to dry the slurry, and subsequently spread it on land. It can be used as fertilizer to fish ponds (Vijay, 2011). The benefits of biogas production include production of an energy resource (biogas), stabilisation of waste (slurry) as soil conditioner, nutrient reclamation and pathogen inactivation.

6. *Mushroom cultivation*

Use of crop wastes (residues) in mushroom production represents a valuable conversion of inedible crop residues into valuable food, which despite their high moisture content has two to three times as much protein as common vegetables and an amino acid composition similar to that of milk or meat. Wheat and rice straws are excellent substrates for the cultivation of *Agaricus bisporus* (white button mushroom) and *Volvariella volvacea* (straw mushroom).

7. *Biochar production*

Biochar is a fine-grained charcoal having high carbon material produced through slow pyrolysis (heating in the absence of oxygen) of biomass. It can potentially play a major role in the long-term storage of carbon in soil. Biochar converted from plant biomass contains a unique recalcitrant form of carbon that is resistant to microbial degradation, therefore can be used as a carbon sequester, when applied to soil.

Effect of recycled organic wastes on soil properties

Incorporation of crop residues into soil or retention on the surface soil has several positive influences on physical, chemical and biological properties of soil.

i). Soil erosion

Leaving substantial amounts of crop residues evenly distributed over the soil surface reduces wind and water erosions, and reduces surface sediment and water runoff.

ii). Soil aggregation

Addition of organic matter to the soil favours formation of aggregates. Structural stability increases due to addition of crop wastes.

iii). Soil bulk density

Incorporation of straw with FYM reduces the bulk density of soil and increases the porosity of the soils.

iv). Soil hydraulic properties

Crop residues increase hydraulic conductivity by improving soil structure, microspores and aggregate stability

v). Soil water holding capacity

Residue incorporation raises organic matter content of the soil leading to improvement in water holding capacity of the soil.

vi). Soil temperature

Mulching with plant residues help to raise the minimum soil temperature in winter due to reduction in upward heat flux from soil and decrease the soil temperature during summer due to shading effect.

vii). Soil moisture

Presence of crop wastes reduces evaporation rate due to increase in amount of residues on the soil surface and helps in retaining surface and helps in retaining moisture in the soil.

viii). Soil organic matter content and quality

Continuous addition of crop residue increases organic matter status of soil. Crop residues favour carbon sequestration in soils.

ix). Nutrient status and availability

Soil organic matter acts as reservoir for essential plant nutrients, prevents leaching of elements, required for growth and increases CEC.

x). Soil pH

The recycled crop residues play an important role in amelioration of soil acidity through the release of hydroxyls especially during the decomposition of residues with higher C:N, and soil alkalinity through application of residues from lower C:N crops, including legumes, oilseeds and pulses.

xi). Cation Exchange Capacity

Soil organic matter as reservoir for essential plant nutrients, prevents leaching of elements, required for growth. Addition of crop residues increases CEC.

xii). Carbon and nutrients in microbial biomass

Increased microbial biomass can enhance nutrient availability in soil as well as act as sink and source of plant nutrients.

xiii). Microbial activity

Crop residues provide energy for growth & activities of microbes & substrates for microbial biomass. Crop residues enhance activities of enzymes such as urease, dehydrogenase and alkaline phosphatase.

Application of sugarcane bagasse and press mud improved the physical condition of soil by reducing bulk density and enhanced the macrospores for better root growth, and ultimately enhanced the cane yield. Increase in soil organic carbon with addition of crop residue was also reported by Karanja *et al.* (2006).

Effect of recycled organic wastes on crop growth

Benefits of application of organic wastes either through compost / vermicompost/ biochar to crops and their response in terms of growth and yield are well documented through several literature. A study on the influence of enriched pressmud compost (comprising of pressmud, sugar industry spent wash and flyash) on the growth and yield of rice at Karaikal, Puducherry revealed that incorporation of 1.25 t/ ha enriched pressmud compost as basal along with required remaining nitrogen through inorganic fertilizer as top dressing in three splits could be recommended for rice crop varieties ADT 36, ADT 43 and ADTRH 1 to realize maximum yield in *kuruvai (kharif)* season (Kalaivanan and Omar Hattab, 2016). Makkar *et al.* (2017) opined that application of vermicompost and vermiwash had positively enhanced growth of both vegetative and reproductive phase of the plant and yield performance of linseed crop in Punjab. Rajput *et al.* (2018) studied the influence of organic amendments on the response of rice at Dehradun and revealed that application of wheat compost and wheat + rice compost served the best farming option for sustainable rice agrosystem in hilly areas of India. Chatterjee and Bandopadhyay (2010) evaluated the influence of the recycling of non-legume and leguminous crop wastes and their combination on the nutrients content through decomposition using vermiworms and revealed that combing the mixture of legumes and non-legumes wastes at 2:1 was found as best substrate for increased nutrient contents, C/N ratio and organic carbon.

Multiple benefits of recycling of crop/ organic wastes

- It acts as a reservoir of plant nutrients and also prevents their losses
- It affects the availability of nutrients by chelation

- It helps in buffering capacity of soil
- It helps in maintaining soil structure
- It helps in transmission of heat
- It is a source of carbon for heterotrophs
- It influences the efficiency of chemicals, their degradability and toxicity
- It helps plant through growth substances
- It reduces the toxicities of pollutants like heavy metals
- It conserves the soil and water
- It is a soil amendment
- It helps in conservation of energy
- It helps in minimization of environmental pollution
- It helps in bridging the fertilizer gap

Conclusion

In the present agricultural system, food shortage and environmental pollution are the main hurdles facing by the mankind. Over dependence on chemical fertilisers and pesticides and non-judicious use of synthetic agrochemicals is posing serious threat to ecological balance. Maintenance of healthy soil has become the need of the hour. The relatively high success of organic recycling depends on the awareness and growing concern on the ill effects of chemical farming on environment. The enormous amount of organic wastes available for recycling should be explored for possible bioconversion to utilize the embedded nutrients of the wastes for sustainable soil health and crop growth. It will not only help to meet the fertilizer nutrients deficit, but also to conserve energy, minimize pollution, save foreign exchange and improve the fertilizer use efficiency. Further scientific research is also needed to explore the hidden potential for more effective, economical and sustainable recycling of organic wastes in agriculture.

References

Amundson, R, Berhe, A.A., Hopmans, J.W., Olson, C., Sztein, A,E. and Sparks, D.L. 2015. Soil and human security in the 21st century. *Science* 348 (6235):647–653.

Chatterjee, R, and Bandyopadhyay, S. 2010. Studies on composting of different crop residues as influenced by earthworm activity. *J. Soil Bio. Eco.,* 30: 169-177.

Chatterjee, R., S. Gajjeta and R.K. Thirumdasu. 2017. Recycling of organic wastes for sustainable soil health and crop growth. *Int. J. waste resour.*,7 (3).

Kalaivanan, D. and K. Omar Hattab. 2016. Recycling of sugarcane industries byproducts for preparation of enriched pressmud compost and its influence on growth and yield of rice (*Oryza sativa L*.). *Int. J. recycl. org. waste agricult.*,5:263–272.

Kimothi, S.P., Sanjeev Panwar and Anjani Khulbe. Creating Wealth from Agricultural Waste. Ed., Indian Council of Agricultural Research, New Delhi, 2020, 172 Pages.

Karanja. N.K., Ajuke, F.O. and Swift, M.J. 2006. Organic resources quality and soil fauna: their role on the microbial biomass, decomposition and nutrient release patterns in Kenyan soils. *Tropical subtropical agroecosyst.*, 6: 73–86.

Makkar,C., Jaswinder Singh and Chander Parkash. 2017. Vermicompost and vermiwash as supplement to improve seedling, plant growth and yield in *Linum usitassimum* L. for organic agriculture. *Int. J.Recycl. Org. Waste Agricult.*, 6:203–218.

Rajput, R., Priya Pokhriya, Pooja Panwar, ,A. Arunachalam and K. Arunachalam. 2018. Soil nutrients, microbial biomass, and crop response to organic amendments in rice cropping system in the Shiwalik of Indian Himalayas. *Int. J.Recycl. Org. Waste Agricult.*, (online), November, 2018.

Reddy, K.S., Kumar, N., Sharma, A.K., Acharya, C.L. and Dalal, R.C. 2005. Biophysical and sociological impacts of farmyard manure and its potential role in meeting crop nutrient needs: a farmers' survey in Madhya Pradesh, India. *Aust. J. Exp. Agri.*, 45 (4): 357-367.

Vijay, V.K. 2011. Biogas enrichment and bottling technology for vehicular use. *Biogas forum* 1(1):12–15.

Volume: 04 Issue No: 12

THE STORY OF FLOWER – DEVELOPMENTAL GENETICS

Article ID: AG-VO4-I12-89

Nivedha R*

Senior Research Fellow, Department of Rice,

Tamil Nadu Agricultural University Coimbatore – 641003, Tamil Nadu, India

*Corresponding Author Email ID: nivedharakkimuthu@gmail.com

Abstract

The flowers of angiosperms have fascinated both humanists and naturalists for a long time. Flowering is an integral developmental process in angiosperms, crucial to reproductive success and continuity of the species through time. The development of human civilization was closely linked to the flower, as seeds and fruit especially grains are the basis of agriculture in both agrarian and modern society. The transition from vegetative to flowering phase involves major changes in the pattern of morphogenesis and cell differentiation at the shoot apical meristem. The major classes of genes involved in transition *viz.*, floral meristem identity genes, floral organ identity genes result in the ultimate expression of floral organs – sepals, petals, stamens and carpels. The flower development models were derived based on the studies in *Arabidopsis thaliana* and *Antirrhinum majus* as model plants. Understanding the genetics and mechanisms behind the flower development becomes necessary for genetically producing new materials that could be potentially used in breeding programs.

Keywords: Flower development, Floral meristems, ABC model, MADS-box genes

Introduction

The origin of flower during the late Jurassic to early Cretaceous periods represented a pivotal evolutionary innovation, reshaping the Earth's ecosystems. Flowering plants (angiosperms) gained dominance through their reproductive efficiency and adaptability, outcompeting other seed plants. Understanding the genetic basis of flower origin and evolution not only illuminates key aspects of organismal development but also holds promise for enhancing food security through bioengineering of crop plants. Floral meristems, distinct from vegetative meristems, are characterized by increased cell division within the shoot apical meristem during reproductive transitions. This shift transforms the meristem into a floral structure, laying the groundwork for flower development.

Floral organs

Floral meristems give rise to four organ types namely, sepals, petals, stamens and carpels, arranged in concentric whorls. The carpels, forming the gynoecium, consume all apical meristematic cells during their development, leaving only the organ primordia in the floral bud. In Arabidopsis, the outermost whorl consists of sepals, followed by petals in the second whorl, stamens in the third, and a gynoecium in the innermost whorl.

Genetics of flower development

Three classes of genes regulate flower development which were identified through mutation.

1. **Floral organ identity genes** The proteins encoded by these genes are transcription factors that likely control the expression of other genes whose products are involved in the formation function of floral organs.
2. **Cadastral genes** act as spatial regulators of the floral organ identity genes by setting boundaries for their expression.
3. **Meristem identity genes** are necessary for the initial induction of the organ identity genes. These genes are the positive regulators of floral organ identity.

Floral meristem identity genes

In Arabidopsis, genes such as AGAMOUS-LIKE 20 (AGL20), APETALA1 (AP1), and LEAFY (LFY) play pivotal roles in floral initiation. AGL20 integrates environmental and internal signals, serving as a master switch for flowering. Once activated, AGL20 induces LFY, which subsequently activates AP1. The feedback loop between LFY and AP1 ensures sustained floral development. In Antirrhinum, the FLORICAULA (FLO) gene is the counterpart to LFY, controlling the establishment of floral meristem identity. The wild-type floricaula (FLO) gene plays a crucial role in establishing floral meristem identity during the determination stage. The gene Terminal flower 1 (TFL1) supports the maintenance of inflorescence shoot meristem identity by inhibiting the signal or source that influences the expression of LFY and AP1.

Floral organ identity genes

The floral organ identity genes are homeotic class of genes. These homeotic genes encode MADS-box transcription factors essential for determining organ identity. MADS-box genes function as key developmental regulators, triggering the complete genetic program for specific structures (Qiao *et al*., 2024). In plants, they govern critical aspects of development, including the formation of male and female gametophytes, embryo and seed development, as well as the growth of roots, flowers, and fruits. Additionally, they play essential roles in determining floral organ identity and the timing of flowering. The MADS BOX genes were originated from different sources *i.e*., **M**CM1 from the budding yeast, *Saccharomyces cerevisiae*, **A**GAMOUS from the thale cress *Arabidopsis thaliana*, **D**EFICIENS from the snapdragon *Antirrhinum majus* and **S**RF from the human *Homo sapiens*. These homeotic genes fall into three classes (A, B and C) each governing specific whorl development. Class A – APETALA 1(AP1), APETALA 2 (AP2), Class B – APETALA 3 (AP3), PIATILLATA (P1) and Class C – AGAMOUS (AG). The widely accepted ABC model explains how these gene activities combine to define sepals, petals, stamens, and carpels, with A and C activities mutually repressing each other.

ABC model of flower development

This model was proposed in 1991 by E S. Coen. & E. M. Meyerowitz in Arabidopsis thaliana and Antirrhinum majus. It demonstrates how combinations of gene activities determine floral organ identity. For instance:

- Type A activity alone specifies sepals
- A and B activities together form petals
- B and C activities produce stamens
- Type C activity alone specifies carpels

Mutations in these genes result in homeotic transformations, where organs develop in incorrect positions, validating the model's predictions.

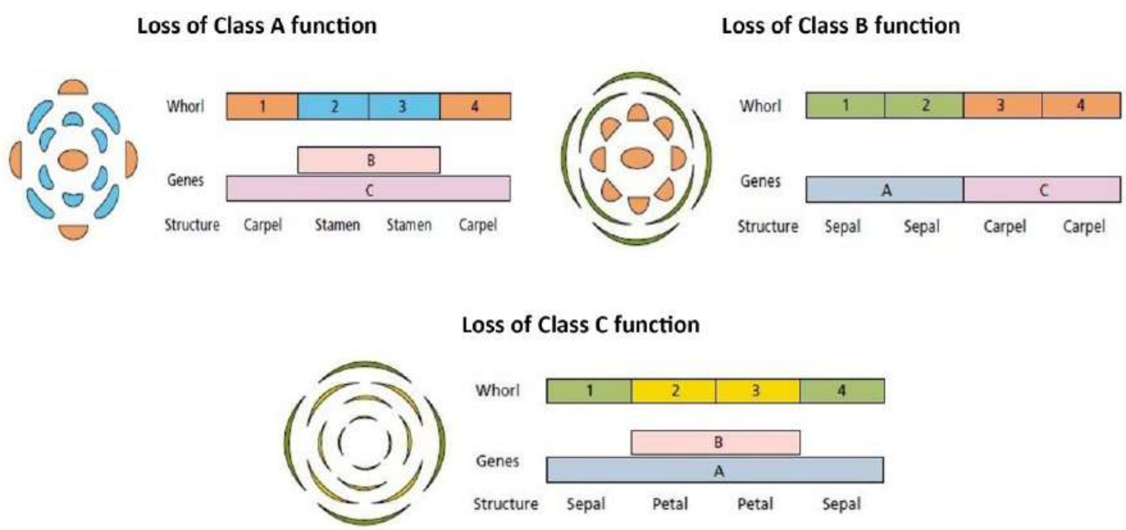
Validation of the ABC model

Genetic studies confirmed the ABC model through floral homeotic mutants:

- Loss of class A activity produces carpels in place of sepals and stamens in place of petals.
- Loss of class B activity results in sepals replacing petals and carpels replacing stamens.

- Loss of class C activity forms petals in place of stamens and replaces carpels with new flowers, creating repetitive floral structures.

Quadruple mutants lacking AP1, AP2, AP3/PI, and AG develop leaf-like structures instead of floral organs, demonstrating the foundational role of these genes in flower development (Bowman and Moyroud, 2024).



Lincoln and Eduardo, 2010

Regulation of flowering

Plants can start flowering at very different times. Some may bloom just weeks after sprouting, while others, like many forest trees, might take 20 years or more before producing flowers. This variation shows that a plant's age or size is an internal factor that helps trigger flowering. When flowering happens solely due to these internal factors, without needing any specific environmental conditions, it is called *autonomous regulation*. However, not all plants flower this way. Some need specific environmental signals, like light or temperature changes, to bloom; this is called an *obligate* or *qualitative* response. Other plants may flower faster with the right environmental conditions but will eventually flower even without them. This is called a *facultative* or *quantitative* response.

Conclusion

The genetic study of flower development in model plants like *Arabidopsis* and *Antirrhinum* has significantly advanced our understanding of similar processes in grasses and other plant families, demonstrating the evolutionary conservation of floral genetics. These insights have practical implications, enabling the development of male-sterile lines for hybrid breeding, the creation of double flowers for ornamental purposes, and the improvement of crop yield stability through reduced seed shattering. Furthermore, genetic modifications can produce unique floral forms, such as the green rose, expanding the possibilities for horticultural innovation. These applications underscore the transformative potential of floral genetic studies in addressing both agricultural and aesthetic challenges, providing a foundation for future advancements in plant science.

References

Taiz Lincoln., Zeiger Eduardo. 2010. Plant Physiology. Sinauer Associates Inc., 720-740.

Bowman JL, Moyroud E. 2024. Reflections on the ABC model of flower development. The Plant Cell. 36(5):1334-1357.

Qiao Z, Deng F, Zeng H, Li X, Lu L, Lei Y, Li L, Chen Y, Chen J. 2024. MADS-Box Family Genes in Lagerstroemia indica and Their Involvement in Flower Development. Plants. 13(5):709.

Volume: 04 Issue No: 12

CONTINGENCY PLANNING FOR AGRICULTURE CROPS IN ABERRANT WEATHER CONDITIONS

Article ID: AG-VO4-I12-90

R. Karthikeyan[1*] and T. Selvakumar[2]

[1]Associate Professor (Agronomy), Directorate of Crop Management,Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

[2]Associate Professor (Agronomy), Maize Research Station, Tamil Nadu Agricultural University, Vagarai, Tamil Nadu, India

*Corresponding Author Email ID: agrikarthialr@gmail.com

Abstract

Rainfed agriculture plays a pivotal role in Indian economy and its livelihoods. Of the total net area, about 60% is rainfed which contributes to about 40% of food production. Agriculture in rainfed areas is ambiguous as the behaviour of rainfall is highly erratic and uncertain. The deviations in rainfall behaviour commonly met with in rainfed areas include delayed onset, early withdrawal and intermediary dry spells during rainy season. The adverse effect of these rainfall aberrations on crop growth vary with the degree of deviation and the crop growth stage at which such deviations occur. Suitable manipulations in crop management practices are essential to minimize such adverse effects of abnormal rainfall behaviour. The management decisions constitute contingency planning. The contingent planning options recommended to manage different weather aberrations are described as hereunder.

Keywords: Aberrant weather, rainfall behaviour, contingency planning, mid-season correction

Introduction

Agriculture is the livelihood for nearly two-thirds of the population in India. A major part of the agriculture in India is rainfed which mainly depends on the monsoon. While some part of the country experiences monsoon failure frequently and frequency of drought occurs once in 2 to 4 years in few states this affect the economy. Frequent weather aberrations makes agriculture and allied sectors highly vulnerable, risk prone and often unprofitable impacting the livelihoods of farmers. During 1972-73, scarcity of rainfall was experienced all over the country, at that time Roving seminars were organized by the ICAR at different locations to form contingent crop planning and mid- season correction as new startegies done in order to reduce losses in agriculture and to prevent the crop failure under aberrant weather conditions such as delay of onset and erratic monsoon rainfall distribution. As a follow up, the AICRPDA (All India Coordinated Research Project for Dry land Agriculture) listed the weather aberrations: (i) delayed onset of monsoon, (ii) early withdrawal of monsoon (iii) intermittent dry spells of various durations, (iv) prolonged dry spells causing changes in the strategy and (v) prolonged monsoon (Rao *et al.*, 2013). It is projected that climate change has its negative impact on both irrigated and rainfed crop yields. However, the rainfed crops are more vulnerable due to less options available to cope up with rainfall variability (Maheswari et al., 2019).

Contingency planning for aberrant weather situations is a method to mitigate unexpected weather events that can affect crops. The goal is to choose the right crops, varieties, and farming practices to address the situation. A real time contingency planning is considered as any contingency measure, either technology related (land, soil, water, crop) or institutional and policy based, which is implemented based on real time weather pattern in any crop growing season. To improve the efficiency of the production systems at the time of weather aberrations, the need is to implement contingency measures on real-time basis.

Aberrant weather

Weather conditions vary considerably not only from year to year but also within the year. This strategy affects the regular cropping systems and causes adverse impact on sowing, growth, development, productivity of crops during cropping seasons. The weather may be aberrant on account of:

- Date of commencement of monsoon rainfall variation in different parts of the country
- Date of cessation of monsoon rainfall variation in year to year in different parts of country
- Quantity of rainfall variation from year to year and the coefficient of variation of rainfall increases with decrease in monsoon rainfall
- High intensity rainfall occurs in association with the movement of cyclones resulting in sizeable loss of rain water through run -off and deep drainage

- Too early onset of monsoon followed by big gap and early withdrawal
- Too early onset of monsoon without big gap and early withdrawal
- Too early onset of monsoon without gap and late withdrawal
- Normal onset with a big gap and late withdrawal
- Late onset of monsoon without big gap and early withdrawal
- Late onset of monsoon with a big gap and late withdrawal

To meet the possible weather aberrations, a few alternate crop production strategies are recommended: -

- Dry seeding of crops like cotton, sorghum, maize, pearl millet and pigeon pea, in case monsoon set is delayed but expected within a week or ten days
- Raising of nursery for rice, millets *etc*. and transplanting after onset of monsoon
- Adoption of closer spacing under delayed sowing of crops
- Intercropping to cope up with the weather aberration during crop season
- Selecting short duration crops and varieties in the event of delayed monsoon

i). Early onset of monsoon followed by big gap and early withdrawal

In this situation soil will get adequate moisture in early monsoon season and following dry period will enable the farmers to prepare seed bed and sowing. Under such situation, farmers should select short duration crop and varieties. The farmers can sow cotton, sorghum, peal millet and groundnut crops as early as soil condition allows the land for sowing.

ii). Early onset of monsoon without gap but early withdrawal

More attention had to be paid to provide field drainage in deep black soils. The inter space between furrows should depend upon crops to be grown like less inter space for maize than sorghum and soybean and less inter-space on deeper soil. In this situation, weed growth will be faster than crop growth so adapting year-round tillage for weed control and inter culture by cultivator is much more efficient than hand hoe.

iii). Pre-monsoon showers

Pre-monsoon dry seeding ensures timely and early sowing. Dry sowing allows full utilization of pre-monsoon showers for better germination, optimum crop stand and growth. Early sowing avoids burden on bullock and human labour for field preparation and sowing. Dry sowing also safeguards crops against pests and diseases incidence. Cotton, sorghum, greengram, blackgran and pigeonpea are extensively sown under pre-monsoon dry seeding condition.

iv). Late onset of monsoon

During some of the years, the onset of monsoon gets delayed so that the crops/varieties which are regularly grown in the region cannot be sown in time. Delayed sowing of the crops can lead to reduced and even uneconomical crop yields. Under such condition, transplanting of crops and selection of crops and varieties which could perform better under late sown conditions are the two options recommended to cope up with the delayed onset of monsoon.

v). Dry spell immediately after sowing

Any dry spell immediately after sowing of crop might result in poor germination and poor establishment of crop stand. To avoid total crop failure, it is better to resow the crop than to continue with inadequate plant stand.

Dry spell after sowing	Mitigation
Immediately after sowing	Gap filling with subsequent rains if stand reduction is less than 20%; re-sowing if stand reduction is more than 20%; mulching between crop rows; stirring soil surface to create dust mulch to reduce evaporation
Vegetative phase	Mulching, antitranspirant spray, spraying Kcl, thinning of 33-50% population
Flowering stage	Antitranspirant spray, harvesting for fodder and ratooning with subsequent rains in millets (e.g.) sorghum
Ripening stage	Antitranspirant spray, harvesting for fodder, harvesting at physiological maturity.

Mid-season correction

Management practices followed after crop establishment and in the middle of crop growth are called mid-season or mid-term corrections. To mitigate the damaging effects of drought after sowing of crop, following mid-season corrections are recommended.

i. Ratooning/ thinning

The rate of soil moisture depletion increases with increasing leaf area. If drought occurs at 40-50 days after sowing, reduction in leaf area either by ratooning or thinning the plant population can mitigate the adverse effects of drought. Sorghum and pearl-millet responds to ratooning. Urea spray @ 2 per cent after drought period is useful for indeterminate crops like castor, pigeon-pea and groundnut.

Plant population must be adjusted to available moisture levels, either within rows or between rows. Beside this, there is a need to go for rational planting geometry for the rational use of available soil moisture. If drought occurs during pre-flowering stage, thinning is useful. Every third plant or alternate row may be removed to reduce the soil moisture loss and preserve it. Moisture stress of 35-50 days can be lessened by such thinning operation.

ii. Mulching

Mulches improve soil water availability to crop plants by reduction in evaporation and run-off, sustaining infiltration rate and controlling weeds and it reduce soil erosion by reducing the velocity of run-off and increasing the rate of infiltration. Repeated inter-cultivations in black soils results in formation of soil mulch on the surface. It act as a barrier to evaporation loss from soil profile. Deep cracks formed due to drought increase the loss of stored water by evaporation. Soil mulch minimize deep cracking leading to reduced evaporation losses.

iii. Weed control

Weeds compete with crop for nutrients, water and other natural resources. Such competition for soil water from weeds can be reduced by timely weed control.

iv. Water harvesting and protective irrigation

For crop life-saving the effective measures are *in-situ* water harvesting and protective irrigation during soil moisture stress

v. Stripping of crop leaves

To reduce transpiration losses, lower leaves of the plant may be excluded because mostly, photosynthesis happens in the 3-4 upper leaves.

vi. Intercropping and risk distribution

Application of meteorological information in terms of the frequency and probability of breaks in monsoon rains can be made to select a combination of crops of different durations in such a way that there is time lag in the occurrence of their growth for appropriate intercropping systems.

Suitable Intercropping systems

• Sorghum + cowpea or pigeonpea in interspaces

• Cotton + blackgram or greengram in paired row system

• Cotton + coriander / Cotton + clusterbean

• Sorghum + cowpea / Sorghum + blackgram / Sorghum + greengram / Sorghum + siratro (fodder)

• Maize + greengram

Delayed onset of rainfall

Delay exceeding 3-4 weeks eg: Delay in South west monsoon	Alternate crops of short duration to be sown
Normal - June Delay - July Delay - August	Groundnut Ragi / pearl millet Samai / cowpea
Delay of 1-2 weeks	Alternate varieties of short duration of same crop eg: sorghum co19 (150 days) Co 25 (110 days) Red gram local (180 days) Co 5 (130 days)

Early Season drought

❖ Resowing within a week to 10 days with subsequent rains for better plant stand when germination is less than 30%

❖ Interculture to breakdown soil crust and eradicate weeds and create soil mulch for conserving soil moisture

❖ Avoid top dressing of fertilizers till favourable soil moisture is attained

❖ Opening conservation furrows at 10 to 15 m intervals

❖ For effective moisture conservation ridge, and furrow across the slope

❖ When the crop stand is less than 75%, pot watering along with gap filling can done in crops like cotton

Terminal Drought

❖ Providing supplemental irrigation

❖ Harvesting crop at physiological maturity with some realizable yield or harvest for fodder.

❖ Prepare for winter (*rabi*) sowing in double- cropped areas.

❖ Ratoon maize or pearl millet or adopt relay crops as chickpea, safflower, *rabi* sorghum and sunflower with minimum tillage after soybean in medium to deep black soils in Maharashtra

- ❖ Prefer contingency crops (horsegram/ cowpea) or dual-purpose forage crops on receipt of showers under receding soil moisture conditions

Recommended *Rabi* Contingency plans for delayed North East monsoon rains

Month	Crop / Intercropping system	Cultural operation
Early October Late October	Pulses, Sorghum, Cotton Pearlmillet, Sunflower, Senna, Coriander	Sowing on receipt of normal monsoon rain If the monsoon is delayed and received during 3 to 4 weeks, sowing will be taken up
Early November Late November	Sunflower, Coriander, Senna For all crops	Sowing can be taken up if rains delayed -1st to 2nd weeks of November Sowing could not be taken up after second -3rd to 4th week of November as the crop will suffer moisture stress at reproductive stages
Early December Late December	For all crops For all crops	Weeding and plant protection for late sown crops

Unseasonal heavy rainfall events

- ❖ Providing surface drainage
- ❖ Application of growth hormones/nutrient sprays to prevent flower drop or promote quick flowering/fruiting
- ❖ At crop maturity stage, prevention of seed germination and harvesting of produce
- ❖ If unfortunate rains occur at vegetative stage, the contingency measures include:
  - ➢ Draining out the surplus water as early as possible
  - ➢ Gap filling with available nursery

- ➢ Suitable plant protection measures in anticipation of pest and disease out breaks
- ➢ Foliar spray with 1% KNO_3
- ➢ Interculture at optimum soil moisture condition to loosen and aerate the soil and to control weeds

- ❖ Draining out of stagnant water and strengthening of field bunds
- ❖ Community nursery raising

It is a known fact that the impact of climate change is experienced all over the world of which the developing countries like India are more vulnerable wherein huge number of population is dependent on agriculture with less risk bearing capacities. It is crucial for enhancing the resilience of agricultural production to climate variability including weather aberrations so as to ensure sustainable farm productivity and inturn achieve the food and nutritional security through adoption of different crop planning strategies.

References

Maheswari, M, B Sarkar, M Vanaja, M Srinivasa Rao, JVNS Prasad, M Prabhakar, G Ravindra Chary, B Venkateswarlu, P Ray Choudhury, DK Yadava, S Bhaskar, K Alagusundaram (Eds.). 2019. Climate Resilient Crop Varieties for Sustainable Food Production under Aberrant Weather Conditions. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. P64.

Prasad, Y.G., Venkateswarlu, B., Ravindra Chary, G., Srinivasarao, Ch., Rao, K.V., Ramana, D.B.V., Rao, V.U.M., Subba Reddy, G. and Singh, A.K. 2012. Contingency Crop Planning for 100 Districts in Peninsular India. Central Research Institute for Dryland Agriculture, Hyderabad 500 059, India. p. 302.

Srinivasa Rao Ch, Ravindra Chary G, Mishra PK, Nagarjuna Kumar R, Maruthi Sankar GR, Venkateswarlu B and Sikka AK. 2013. Real Time Contingency Planning: Initial Experiences from AICRPDA. All India Coordinated Research Project for Dryland Agriculture (AICRPDA), Central Research Institute for Dryland Agriculture (CRIDA), ICAR, Hyderabad -500 059, India. 63 p.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

EFFLUENT DISCHARGES AND THEIR COMPOSITION: INSIGHTS FROM VARIOUS INDUSTRIAL SECTORS IN INDIA

Article ID: AG-V04-I12-91

***[1]S. Barathkumar, [2]A. Chitra Devi**

[1]Department of Soil Science and Agricultural Chemistry, Adhiyamaan College of Agriculture and Research, Krishnagiri, Tamil Nadu, India – 635 105

[2]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India - 641003

*Corresponding Author Email ID: barathkumar.pgsac2022@tnau.ac.in

Abstract

The soil and water quality were important for both human health and ecosystem balance. The effluent of major industrial sectors, including tannery, sugar, paper and pulp, leather, food processing, and chemical industries in India were crucial to investigate its nature. Each sector generates distinct pollutants, such as heavy metals, organic matter, nutrients, and suspended solids, posing significant environmental challenges. Effluents from tanning and chemical industries are particularly toxic due to high chromium and non-biodegradable organics, while food and sugar industries contribute biodegradable pollutants. Effective treatment strategies, including biological, physicochemical, and advanced oxidation processes, are critical for mitigating these impacts. Sustainable practices, regulatory compliance, and advanced treatment technologies are recommended to reduce pollution and promote environmental protection.

Introduction

The introduction of industries on one hand manufactures useful products but at the same time generates waste products in the form of solid, liquid or gas that leads to the creation of hazards, pollution and losses of energy. Most of the solid wastes and wastewaters are discharged into the soil and water bodies and thus ultimately pose a serious threat to human and routine functioning of ecosystem. Industrial effluents, the wastewater discharged by industries during production processes, vary significantly in composition based on the type of industry, raw materials used, and manufacturing methods. These effluents often contain a complex mixture of organic and inorganic pollutants, including heavy metals, toxic chemicals, nutrients, and suspended solids. The characteristics of these discharges can profoundly impact water quality, soil health, and ecosystems if left untreated. Different industries generate unique effluents based on their activities. For instance, sugar factories often release effluents rich in organic matter and nutrients, while iron and steel plants contribute high concentrations of heavy metals such as cadmium. Similarly, textile units are known for dyes and chemicals, and food processing industries typically produce biodegradable organic waste. Evaluating these properties is critical to understanding their environmental impacts and designing appropriate treatment methods. This evaluation enables the development of sustainable practices, compliance with environmental regulations, and the mitigation of adverse effects on ecosystems and human health. By identifying effluent characteristics across industries, stakeholders can implement targeted strategies to manage and treat wastewater effectively, ensuring a balance between industrial development and environmental protection.

Major Industrial Sectors

India's major industrial sectors include agriculture-based industries, such as sugar, textiles, and food processing, which leverage the nation's agrarian economy. The iron and steel industry forms the backbone of infrastructure development, while the chemical and pharmaceutical sectors cater to domestic needs and global exports. The energy sector, including thermal, hydro, and renewable energy, powers industrial growth. Automobile and manufacturing industries are significant contributors to GDP and employment. Additionally, the IT and software services sector plays a pivotal role in India's economic growth, alongside mining and cement industries, which support construction and raw material supply. Together, these sectors drive India’s industrial landscape and economic progress.

Tanning Industry

The tannery industry involves multiple stages, each producing wastewater with distinct pollutants. Soaking generates effluents high in TDS (36,500 mg/l), BOD (1850 mg/l), and COD (4600 mg/l), which can be mitigated through water-efficient soaking techniques and pre-soaking treatments. Liming and unhairing produce alkaline wastewater with sulfides and suspended solids (9000 mg/l), requiring lime recovery and biological treatments. Deliming and bating release ammonium salts and organic matter, manageable with alternative agents and enhanced biological processes. Pickling effluents, rich in chlorides (23,500 mg/l) and acidity, necessitate neutralization and reuse of agents. Chrome tanning contributes high chromium and COD (6300 mg/l), treatable with advanced oxidation and alternative tanning agents. Retanning effluents contain residual syntans and oils, addressable with closed-loop systems and biodegradable syntans. The tannery industry generates wastewater containing high BOD, COD, TDS, and suspended solids, along with toxic contaminants like chromium, sulfides, ammonium salts, chlorides, and refractory tannins. These pollutants harm aquatic ecosystems, deplete oxygen, alter pH, and contribute to nutrient pollution and toxicity. General strategies include pre-treatment, biological treatment, advanced oxidation, recycling, and regulatory compliance. Sustainable practices and effective wastewater management are crucial to reducing the environmental footprint of tannery operations.

Sugar Industry

The sugar processing industry involves multiple stages, including juice extraction, clarification, evaporation, crystallization, and drying, each contributing to wastewater generation with distinct compositions. Wastewater from the mill house contains oil, grease (up to 48 mg/L), and TSS (up to 228 mg/L) from cane crushing and floor washing, while the process house discharges water with high BOD (up to 355 mg/L), COD (up to 1190 mg/L), and TSS from juice processing activities. Boiler house operations add TSS and oil contaminants, and pollutants like TSS (up to 660 mg/L), BOD (up to 673 mg/L), COD (up to 3683 mg/L), oil and grease (up to 134 mg/L), and pH imbalances are common across stages. The presence of organic matter, suspended solids, nutrients, and toxic metals makes untreated wastewater harmful to the environment. Effective treatment methods include physicochemical techniques like coagulation, flocculation, sedimentation, and filtration to reduce turbidity, and biological treatments like activated sludge and anaerobic digestion to degrade organic matter while producing biogas. Advanced oxidation processes, such as ozonation and UV treatment, break down complex pollutants, while nutrient removal methods, including nitrification/denitrification and phosphorus precipitation, mitigate eutrophication risks. Recycling treated effluent for irrigation or industrial processes and employing water pinch analysis optimize water usage and reduce wastewater generation. These measures enhance wastewater quality, minimize environmental harm, and promote sustainable practices in the sugar industry.

Paper and Pulp industry

The paper processing industry is known for high water consumption and wastewater generation, containing various pollutants. The process includes raw material preparation, pulping, bleaching, sheet formation, and drying. Wastewater from this industry exhibits key parameters: raw wastewater pH ranges from 6.8 to 7.1, while treated wastewater has a pH of 7.1 to 7.3. Suspended Solids (SS) in raw wastewater range from 1160 to 1380 mg/l, dropping to 322 to 505 mg/l after treatment. Total Dissolved Solids (TDS) vary from 1043 to 1293 mg/l in raw wastewater, decreasing to 807 to 984 mg/l post-treatment. Biochemical Oxygen Demand (BOD) is 268-387 mg/l in raw wastewater and 176-282 mg/l in treated wastewater, while Chemical Oxygen Demand (COD) ranges from 1110 to 1272 mg/l, reducing to 799 to 1002 mg/l after treatment. Major pollutants include lignin derivatives, chlorinated compounds, fatty acids, tannins, suspended solids, and sulfur compounds. Treatment methods include physical processes like sedimentation and filtration, chemical processes such as coagulation and chlorination, biological treatments like the activated sludge process, and advanced oxidation processes (AOPs). Recycling and closed-loop systems further help reduce wastewater generation and improve effluent quality.

Leather Industry

The leather industry involves several processing stages that contribute to the generation of effluents with distinct pollutants. Key stages include soaking to remove salt and dirt; liming and un-hairing with lime; de-liming and bating to soften hides using enzymes; and pickling and chrome-tanning, where hides are treated with acidic solutions and chromium salts. Additional steps such as re-tanning, dyeing, fat-liquoring, and finishing enhance leather properties but produce effluents with alarming pollution levels. Composite tannery effluents often exhibit a yellowish-brown color and contain Total Suspended Solids (TSS) up to 1200 mg/L, Total Dissolved Solids (TDS) around 2500 mg/L, Biochemical Oxygen Demand (BOD5) as high as 800 mg/L, and Chemical Oxygen Demand (COD) reaching 1500 mg/L. Sulfates may reach 500 mg/L, while heavy metals like chromium exceed 0.5 mg/L, far surpassing permissible limits. These pollutants pose severe risks to ecosystems and human health, necessitating robust remediation strategies. Installing Effluent Treatment Plants (ETPs) is critical for removing heavy metals and organic pollutants, while bioremediation, chemical precipitation, and membrane filtration provide effective supplementary solutions. Awareness and training programs for industry stakeholders further support sustainable practices. Addressing these effluents' environmental challenges is essential to ensure the sustainability and safety of leather processing operations.

Food Processing Industry

The food industry, particularly the dairy and meat processing sectors, generates wastewater with distinct characteristics that require targeted remediation. The dairy industry involves processes like milk pasteurization, cheese production, and butter making, resulting in effluents with high Chemical Oxygen Demand (COD) of 10,251.2 mg/l, Biochemical Oxygen Demand (BOD) of 4,840.6 mg/l, Total Suspended Solids (TSS) of 5,802.6 mg/l, and significant levels of nitrogen (663 mg/l) and phosphorus (153.6 mg/l). Similarly, the meat industry, encompassing slaughter, processing, and packaging, produces wastewater with COD of 1,683.6 mg/l, BOD of 863.4 mg/l, TSS of 640.2 mg/l, and elevated nitrogen (2,743.6 mg/l) and phosphorus (328.4 mg/l) levels. Pollutants include organic matter, proteins, lipids, blood, chlorides, and nutrients, leading to high biodegradability. Biological treatments, such as activated sludge and anaerobic digestion, effectively reduce organic pollutants. Minimizing product loss, substituting high-phosphorus cleaning agents, and managing salt through brine reuse can mitigate contamination. Advanced technologies like membrane filtration and reverse osmosis further lower pollutant levels, ensuring compliance with environmental standards and promoting sustainability in the food industry.

Chemical Industry

The chemical industry involves diverse processes, generating effluents with varying characteristics that demand tailored remediation strategies. In a building and construction chemicals factory, the production of concrete admixtures, coatings, and bitumen emulsion generates 11-15 m^3/d of wastewater with high COD (2912 mg O_2/l), BOD (150 mg O_2/l), phenol (0.3 mg/l), oil and grease (149-600 mg/l, average 371 mg/l), and TSS (200 mg/l). Pollutants include non-biodegradable organics, phenols, and suspended solids. Biological treatment, such as the activated sludge process, requires nutrient adjustments, while chemical treatments with lime and ferric chloride or aluminum sulfate effectively coagulate pollutants. In a plastic shoes manufacturing factory, wastewater mixed with domestic sewage reached COD levels of 5239 mg O_2/l, BOD of 2615 mg O_2/l, and phenol of 0.5 mg/l. Pollutants include phenols and organic compounds. Biological treatments, like activated sludge or rotating biological contactor systems, are effective due to the dilution with domestic wastewater, which reduces organic loads. These cases emphasize the importance of identifying effluent characteristics to implement effective treatment strategies.

Conclusion

Industrial effluents vary significantly across sectors, reflecting diverse processes and raw materials. Untreated discharges can degrade water and soil quality, harm ecosystems, and pose health risks. This study highlights the need for tailored treatment methods, such as biological and chemical treatments, to address specific pollutants like chromium, sulfides, organic matter, and nutrients. Sustainable management practices, including recycling, bioremediation, and closed-loop systems, can minimize environmental impacts. Promoting awareness, adopting cleaner technologies, and enforcing strict regulations are essential for achieving a balance between industrial growth and environmental sustainability.

References

Hassen, A. S., & Woldeamanuale, T. B. (2017). Evaluation and Characterization of Tannery Wastewater in each process at batu and modjo tannery, Ethiopia. *Int J Environ Sci Nat Res*, *8*(2), 555732.

Fito, J., Tefera, N., Kloos, H., & Van Hulle, S. W. (2019). Physicochemical properties of the sugar industry and ethanol distillery wastewater and their impact on the environment. *Sugar Tech*, *21*, 265-277.

Poddar, P. K., & Sahu, O. (2017). Quality and management of wastewater in sugar industry. *Applied Water Science*, *7*, 461-468.

Esmaeeli, A., Sarrafzadeh, M. H., Zeighami, S., Kalantar, M., Bariki, S. G., Fallahi, A., & Ghaffari, S. B. (2023). A comprehensive review on pulp and paper industries wastewater treatment advances. *Industrial & Engineering Chemistry Research*, *62*(21), 8119-8145.

Chowdhury, M., Mostafa, M. G., Biswas, T. K., Mandal, A., & Saha, A. K. (2015). *Characterization of the effluents from leather processing industries. Environ Process 2: 173–187*.

Aderibigbe, D. O., Giwa, A. R. A., & Bello, I. A. (2017). Characterization and treatment of wastewater from food processing industry: A review. *Imam Journal of Applied Sciences*, *2*(2), 27-36.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

BACTERIAL LEAF BLIGHT OF RICE: A GLANCE

Article ID: AG-VO4-I12-92

***L.Vengadeshkumar[1] and T.Meera[2]**

[1]Assistant Professor (Plant Pathology) Agricultural College and Research Institute, Tamil Nadu Agricultural University, Keezhvelur, Nagapattinam, Tamil Nadu, India

[2]Assistant Professor (Plant Pathology) School of Agriculture, Vels Institute of Science Technology and Advanced Studies,Pallavaram, Chennai 600117, T.N., India

*Corresponding Author Email ID: vengadpragathi@gmail.com

Introduction

Rice bacterial leaf blight, caused by the pathogenic bacterium *Xanthomonas oryzae* pv. *oryzae* (Xoo), stands as a formidable challenge to rice cultivation, a staple food source for a significant portion of the global population. The disease poses a constant threat to rice production, causing substantial yield losses and impacting the livelihoods of millions of farmers. The pathogen causes infiltrates rice plants, eliciting a cascade of symptoms that manifest as distinctive lesions on leaves. These lesions, often starting as water soaked spots, can rapidly expand, leading to the withering and eventual death of affected tissue. The bacterial blight not only compromises the physiological health of crop but also undermines its ability to reach full yield potential. The transmission of pathogen occurs through various avenues, including infected seeds, waterborne dissemination and wind driven rain. Environmental factors, such as high humidity and specific agricultural practices like overhead irrigation contribute to the propagation of the disease. As a consequence, effective management strategies are imperative to curtail the spread of rice bacterial leaf blight. In response to the persistent threat of this bacterial pathogen, ongoing research endeavours aim to unravel the molecular intricacies of the plant-bacterium interaction. This knowledge is pivotal in developing resilient rice varieties through selective breeding and genetic engineering, bolstering the plant's innate defences against Xoo. This introduction sets the stage for a comprehensive exploration of rice bacterial leaf blight, delving into its symptoms, modes of transmission, management strategies, and the global significance of combatting this agricultural menace. As we navigate the complexities of this disease, the collaborative efforts of farmers, researchers, and policymakers emerge as crucial elements in safeguarding rice crops and ensuring food security in regions heavily reliant on this vital cereal.

Pathogen Characters

Taxonomy:

- Domain: Bacteria
- Phylum: Proteobacteria
- Class: Gammaproteobacteria
- Order: Xanthomonadales
- Family: Xanthomonadaceae
- Genus: *Xanthomonas*
- Species: *Xanthomonas oryzae*
- Pathovar: *oryzae*

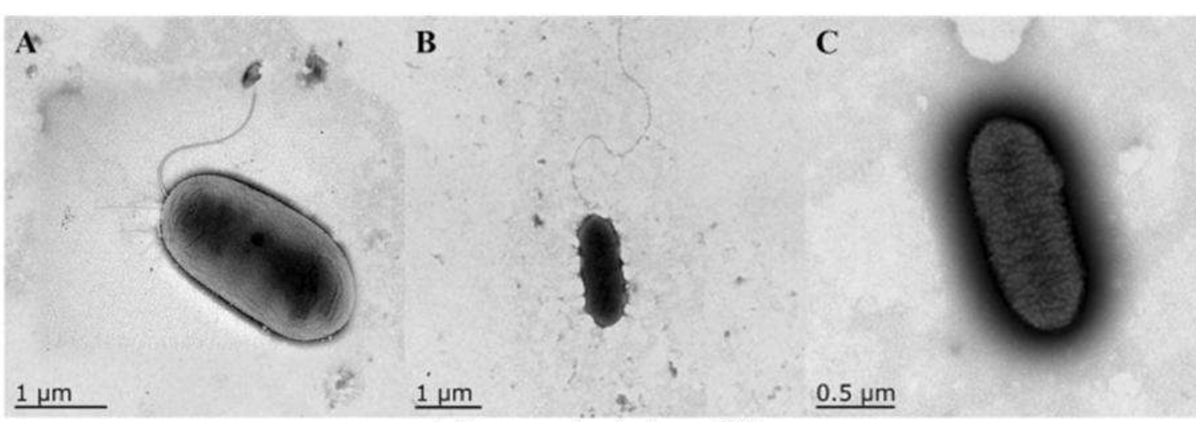
Morphology:

- Cell shape: Rod-shaped (Bacilli) 1.2 x 0.3-0.5 µm.
- Cell arrangement: Single or in pairs
- Gram staining: Gram-negative

-Most strains of Xoo are motile due to the presence of flagella, facilitating movement in the aqueous environment.

-Color: Creamy, yellowish, or translucent on agar media

-Texture: Smooth and mucoid



Microscopic picture of *Xoo*

-Type III Secretion System (T3SS): Xoo employs a type III secretion system to deliver effector proteins into the plant cells. These effectors manipulate host cellular processes and contribute to the pathogenicity of the bacterium.

- Exopolysaccharides: The production of extracellular polysaccharides contributes to the formation of biofilms, aiding in bacterial attachment to plant surfaces and evasion of the host's defence mechanisms.

Toxins: Some strains produce toxins that contribute to disease symptoms

Symptom

The primary symptom is the presence of lesions on the leaves. Lesions are initially water-soaked, appearing as small, dark green spots. As the disease progresses, lesions elongate and merge, forming irregularly shaped, yellowish-brown streaks. Infected leaves often exhibit a blighting effect, leading to the withering and death of affected tissue.

Symptom of Bacterial Leaf Blight

The blighting can extend along the leaf veins and result in the drying and curling of the leaves. In addition to leaf symptoms, bacterial leaf blight can also affect leaf sheaths. Lesions may occur on leaf sheaths, leading to elongated streaks and blighting of the sheath tissue. Under high humidity conditions, bacterial ooze may be observed on the surface of lesions. This ooze contains large numbers of bacterial cells and is a key factor in the spread of the disease. In some cases, the disease can progress to affect the panicles (flowering structures) of the rice plant. Lesions on panicles can result in grain discoloration and reduced seed quality. Severe infections can lead to systemic effects, causing overall stunting and reduced growth of the rice plant. Yield losses are a significant consequence of bacterial leaf blight. Lesions often lead to necrosis (death of plant tissue), affecting the overall health and productivity of the plant.

Epidemiology

- Temperature: Optimal growth occurs at temperatures between 25-30°C.
- Humidity: High humidity and free moisture on plant surfaces favour disease development.

Survival and dissemination

- Seed borne: The pathogen can be transmitted through infected seeds.
- Water and rain: Transmission occurs through water, and rain driven splashes disseminate bacteria from infected to healthy plants.
- Wind: Though less common, wind-driven rain can contribute to bacterial dissemination.

Management

Planting rice varieties that are resistant or tolerant to bacterial leaf blight is one of the most effective strategies. Resistant varieties help reduce the severity of the disease. (IR-20, IR-72, PONMANI, TKM 6). Implementing seed treatment with bactericides can help control the transmission of the pathogen through infected seeds. Seed treatment with bleaching powder (100g/l) and zinc sulfate (2%) reduce bacterial blight. Rotate rice with non-host crops to break the disease cycle. This can reduce the inoculum in the soil and minimize the risk of infection in subsequent rice crops. Remove and destroy infected plant debris to reduce the source of inoculum. This includes removing and burning affected plant material after harvest. Avoid overhead irrigation, if possible, as this can help minimize the spread of the bacteria through water splashes.

Use alternative irrigation methods such as drip or furrow irrigation. Continuously evaluate and promote the cultivation of rice varieties with genetic resistance to bacterial leaf blight. Regularly update varieties to incorporate new sources of resistance. Explore the use of beneficial microorganisms or antagonistic bacteria that can compete with the pathogen. Biological control agents may offer sustainable alternatives to chemical treatments. Spray neem oil 3% or NSKE 5%. In cases of severe outbreaks, chemical control may be necessary with copper-based bactericides. However, their effectiveness can vary, and it's essential to follow recommended dosage and application guidelines. Spray Streptomycin sulphate + Tetracycline combination 300 g + Copper oxychloride 1.25kg/ha. If necessary, repeat 15 days later. Foliar spray with copper fungicides alternatively with Strepto-cyclin (250 ppm) to check secondary spread.

Conclusion

The management of rice bacterial leaf blight demands a multifaceted and proactive approach, given the significant threat it poses to one of the world's primary food sources. As a disease caused by the bacterium *Xoo*, its impact on rice crops can be devastating, leading to yield losses and compromising food security, particularly in regions heavily dependent on rice cultivation. Efforts to combat rice bacterial leaf blight should be anchored in the understanding of the pathogen's characteristics, the dynamics of its interaction with rice plants, and the environmental factors that contribute to its spread. The adoption of resistant rice varieties stands out as a pivotal strategy, providing a sustainable and long-term solution to mitigate the impact of the disease. Ongoing research in genetic resistance, molecular biology, and crop breeding plays a critical role in developing varieties that can withstand the onslaught of the bacterium. Cultural practices, such as crop rotation, field sanitation, and water management, contribute to breaking the disease cycle and reducing the inoculum in the environment. Integrated pest management (IPM), incorporating biological control agents and judicious use of chemical treatments, offers a comprehensive and environmentally sustainable approach to disease control. In regions like India, where rice is a dietary staple and a major economic commodity, farmer education and awareness are key components of successful disease management. Empowering farmers with knowledge about the symptoms of bacterial leaf blight, the importance of choosing resistant varieties, and the implementation of best agricultural practices can enhance their capacity to respond effectively to outbreaks.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

TANNER'S CASSIA- MEDICINALY VALUED GREEN LEAF MANURE TREE

Article ID: AG-VO4-I12-93

[1]Praveen, R.,., [2*]V. Krishnan, V., [1]K. Preetha, [1]S. Lakshmipriya, [1]J. Arathi, and [1]S. Aparna

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

Tanner's Cassia, botanically called *Senna auriculata* (2n: 28), belonging to sub family Caesalpinoideae, is an important leguminous green leaf manure tree crop. It is commonly called Matura tree and as Avaram in Tamil. It occurs in dry regions of India and Sri Lanka. It is commonly found along the sea coast and the dry zones. *Senna auriculata* is suitable for landscaping roadways and home gardens. It tolerates drought and dry conditions, but not much cold. The flowers in racemes are also attractive. It starts flowering and fruiting at the age of 2-3 years. Once established, it flowers precociously and abundantly throughout the year. It prefers properly drained soil.

BOTANICAL DESCRIPTION OF TANNER'S CASSIA TREE

Habitat: Found in dry deciduous forest. Widely distributed, even in poor soils, locally abundant in plains up to 900m.

Habit: An evergreen, fast-growing, much branched shrub or small tree up to 7 m tall.

Root: Deep tap root with many branches having root nodules

Stem: Trunk up to 20 cm in diameter with a thin, reddish brown, lenticellate bark. It has many ascending branches

Leaves: Paripinnate, leaflets 8-12 pairs, each pair with an erect, linear gland between them, oblong, obovate, obtuse or emarginated, mucronate, base rounded, stipules large, leafy, obliquely cordate, reflexed.

Inflorescence: Axillary corymbose racemes few-flowered, short, erect, crowded in axils of upper leaves.

Flower: Flowers are irregular, bisexual, bright yellow and large; the pedicels glabrous and 2.5 cm long

Calyx: Calyx segments concave

Corolla: petals 5, long-clawed, crisp-margined, veined with orange.

Androecium: Stamens 10, the Upper three stamens are reduced to staminodes

Gynoecium: ovary is superior, unilocular, with marginal ovules.

Fig. 1. ***Senna auriculata*- Tanner's Cassia: Botanical illustration**

Fruit: The fruit is a short legume, 7.5–11 cm long, 1.5 cm broad, oblong, obtuse, tipped with long style base, flat, thin, papery, undulately crimpled, pilose, pale brown. 12-20 seeds per fruit are carried each in its separate cavity.

Seed: Seeds compressed ovoid-cylindrical, 7–9 mm × 4–5 mm, with a distinct areole on each face.

Pollination: Cross-pollinated by bees.

Center of Origin: South East Asia including India, Burma and Sri Lanka

RELATED SPECIES

Senna alata -Emperor Candle stick

Senna siamea - Siamese Senna

Senna spectabilis - Ornamental Senna

USES OF SENNA

1. Senna is a beautiful tree for landscaping, roadways and for home gardens.
2. The dried flowers and flower bud tea is taken to treat hyperglycaemia and hyperlipidaemia and for longevity of life.
3. Root decoction is used to treat against fever, diabetes, urinary infections and constipation.
4. The leaves have laxative properties.
5. Senna is an indigenous source of tannins.
6. The flowers are used for religious rituals.
7. The flower buds are crushed and applied on the forehead of children to cure headache.
8. The stem bark is used to stupefy fish to catch them.
9. Fermented mixture of pound bark and dissolved molasses is used as an alcoholic beverage.
10. The wood is used for making tool handles.
11. The bark are used as astringent and are used for gargle.
12. This tree is planted to revegetate eroded as well as sodic soils.
13. Black colour dye is obtained from the bark of Senna.
14. A fast yellow colour dye is obtained from flowers.
15. Boiled seeds are important ingredient in indigo dye.
16. Fiber obtained from inner bark are used to make cordage.

GREEN LEAF MANURE VALUE OF SENNA

The leaves and toppings are used as green leaf manure for paddy soils as a source of nitrogen and potash. The tree is coppiced after three years of establishment. Thereafter, it can be coppiced annually. The coppiced tree regrows well. The nutrient content of leaves of Senna contains 3.08% nitrogen, 1.56% Phosphorus and 2.31% potash.

ADVANTAGES OF SENNA

1. It is a fast-growing tree, yielding sufficient green leaves, within three years of establishment.
2. It is effective in reclaiming sodic soil as a natural source of replacement for gypsum.
3. It can be used to reclaim soils of arid and semi-arid regions including ravines, gullies and sand dunes.
4. It is a drought tolerant tree for a certain period of dry spell in a year.
5. It act as soil binder to prevent soil erosion in sandy soils.
6. It is useful for bee foraging.
7. It can grow well in clayey soil.

LIMITATIONS OF SENNA

1. It is not tolerant to waterlogging condition
2. Senna act as an alternate host for Peanut Chlorotic streak caused by Caulimo virus.

Volume: 04 Issue No: 12

APPLICATION OF INTEGRATED AQUACULTURE SYSTEM

Article ID: AG-VO4-I12-94

S. A. Raj Vasanth[1*], G. Gobi[2], R. Dinesh[3], V. Ranjith Kumar[2]

[1]Fisheries College and Research Institute, Thoothukudi-628 008.

[2]Dr M.G.R. Fisheries College and Research Institute, Ponneri-601 204.

[3]Central Institute of Fisheries Education, Mumbai-400 061.

*Corresponding Author Email ID: raaathiraj@gmail.com

Abstract

Innovative, sustainable methods of aquaculture that connect aquaculture with other farming operations or combine various aquaculture practices are known as integrated aquaculture systems (IAS). Through encouraging a synergistic relationship between the components, these systems seek to maximize resource utilization, minimize environmental effects, and increase economic rewards. Incorporating fish farming with cattle, crops, or other aquatic species like seaweed or shellfish are typical examples. By enabling nutrient recycling, the process of using waste from one component as a resource for another this integration lowers the demand for outside inputs and helps to mitigate pollution. In both urban and rural areas, IAS also support increased food security, resistance to market swings, and biodiversity. This approach excels in addressing environmental issues and promoting socioeconomic advantages while promoting sustainable food production.

Keywords: Aquaculture Practices, Sustainable Methods, IAS, Resource.

Introduction:

A crucial part of the world's food production is aquaculture, the technique of raising aquatic organisms like fish, molluscs, crabs, and aquatic plants. With the increasing demand for sustainable food systems, integrated aquaculture systems (IAS) have emerged as an innovative and environmentally conscious approach to aquaculture.

Principles of Integrated Aquaculture Systems:

Integrated aquaculture systems are characterized by their use of symbiotic relationships among different species and processes within the aquaculture environment. These systems aim to optimize resource utilization, reduce waste, and minimize the environmental footprint of aquaculture operations. The primary principle behind IAS is the integration of various trophic levels within the ecosystem. For instance, in a polyculture system, fish can be combined with other species such as mollusks or seaweeds that utilize the waste products generated by the fish. This creates a self-sustaining loop that improves overall efficiency. A common type of IAS is Integrated Multi-Trophic Aquaculture (IMTA), where different species are grown together in a manner that mimics natural ecosystems. For example, fish such as salmon may be cultivated alongside filter-feeding bivalves like mussels, which consume organic particles, and seaweed, which absorbs dissolved nutrients like nitrogen and phosphorus. This integration not only reduces waste but also diversifies the outputs of the aquaculture system, enhancing economic resilience.

Benefits of Integrated Aquaculture Systems:

Environmental Sustainability:

One of the most significant benefits of IAS is their potential to mitigate environmental impacts associated with traditional aquaculture practices. By recycling nutrients and reducing the reliance on external inputs, these systems minimize pollution in aquatic ecosystems. For example, the integration of seaweed and bivalves can help mitigate eutrophication—a common issue in intensive aquaculture—by removing excess nutrients from the water.

Economic Efficiency

IAS can improve economic efficiency by diversifying production. Farmers can harvest multiple species, reducing dependence on a single product and increasing profitability. Moreover, the reuse of resources such as waste reduces operational costs, making these systems economically viable for small-scale and large-scale producers alike.

Resilience and Stability

The incorporation of multiple species in IAS enhances system resilience. Disease outbreaks or market fluctuations affecting one species are less likely to devastate the entire operation. This resilience is particularly important in the face of climate change and other global uncertainties that threaten food security.

Improved Product Quality

Species grown in IAS often exhibit better quality due to the more natural and balanced environment. For instance, seaweeds cultivated in nutrient-rich waters of an IAS may have higher nutritional content, while fish reared in cleaner, multi-trophic environments often have improved health and growth rates.

Challenges of Integrated Aquaculture Systems

Despite their numerous advantages, IAS face several challenges that need to be addressed for wider adoption.

Technical Complexity

Implementing IAS requires a deep understanding of ecological interactions and system dynamics. The design, management, and maintenance of these systems demand specialized knowledge and expertise, which can be a barrier for traditional aquaculture practitioners.

Initial Investment

The establishment of IAS often involves higher initial costs compared to conventional systems. Farmers need to invest in infrastructure, technology, and training, which may deter adoption, especially in resource-constrained settings.

Market and Policy Barriers

Markets for secondary products such as seaweed or bivalves may not be well-developed in certain regions, limiting the economic benefits of IAS. Additionally, policies and regulations in many countries are not yet adapted to support integrated approaches, creating bureaucratic hurdles for farmers.

Environmental Risks

While IAS aim to reduce environmental impacts, improper implementation can lead to issues such as the introduction of invasive species, imbalances in nutrient cycling, or disease transmission among cultured species. These risks underline the importance of careful planning and monitoring.

Applications of Integrated Aquaculture Systems:

Integrated Multi-Trophic Aquaculture (IMTA)

IMTA systems are widely used in coastal aquaculture operations. For instance, in Canada, salmon farms have integrated mussels and kelp to reduce nutrient loads and diversify production. Similarly, in China, traditional polyculture systems combine carp, shrimp, and aquatic plants in freshwater ponds, leveraging natural nutrient cycles for productivity.

Rice-Fish Farming Systems

Rice-fish farming is an ancient practice that exemplifies the principles of IAS. Fish such as tilapia or carp are raised in flooded rice paddies, where they feed on pests and weeds while fertilizing the crops with their waste. This system has been revitalized in countries like Bangladesh, Vietnam, and Indonesia, significantly improving yields and farmer incomes.

Aquaponics

Aquaponics integrates aquaculture with hydroponics, where fish are reared in tanks and their nutrient-rich wastewater is used to grow plants. This closed-loop system is gaining popularity in urban and peri-urban areas, offering a sustainable solution for food production in space-constrained environments. Examples include commercial aquaponics ventures in the United States and Australia, which produce vegetables and fish for local markets.

Coastal Lagoon Systems

In Mediterranean countries, traditional coastal lagoon aquaculture systems are being modernized using IAS principles. These systems integrate fish farming with salt-tolerant crops and shellfish cultivation, enhancing biodiversity and economic output while maintaining the ecological balance of the lagoon environment.

Future Prospects and Innovations

The future of IAS lies in technological innovation and broader policy support. Advances in monitoring tools, such as sensors and artificial intelligence, are making it easier to manage complex integrated systems. Real-time data on water quality, nutrient levels, and species health can optimize system performance and reduce risks. Research into species compatibility and nutrient cycling is expanding the range of species that can be integrated into IAS. For example, efforts are underway to incorporate higher-value species such as abalone or ornamental fish into existing systems. Similarly, the development of biofilters and engineered ecosystems is enhancing the scalability of IAS in industrial settings. Policy frameworks need to evolve to promote IAS adoption. Governments can incentivize sustainable practices through subsidies, grants, and streamlined regulations. Education and training programs for farmers are also essential to build the technical capacity required for IAS implementation.

Conclusion

Integrated aquaculture systems represent a promising pathway toward sustainable and resilient food production. By harnessing ecological principles and embracing innovation, IAS can address many of the environmental, economic, and social challenges facing modern aquaculture. While hurdles such as technical complexity and initial costs remain, the benefits of IAS including reduced waste, diversified outputs, and enhanced resilience far outweigh these challenges. As global demand for seafood and aquatic products continues to rise, integrated approaches will play a pivotal role in ensuring the sustainability and efficiency of aquaculture systems.

References

Edwards, P. (1998). A systems approach for the promotion of integrated aquaculture. Aquaculture Economics & Management, 2(1), 1-12.

Folke, C., & Kautsky, N. (1992). Aquaculture with its environment: prospects for sustainability. Ocean & coastal management, 17(1), 5-24.

Pillay, T. V. R. (1997). Economic and social dimensions of aquaculture management. Aquaculture Economics & Management, 1(1-2), 3-11.

Prein, M. (2002). Integration of aquaculture into crop–animal systems in Asia. Agricultural systems, 71(1-2), 127-146.

Pullin, R. S., & Shehadeh, Z. H. (1980). Integrated agriculture-aquaculture farming systems. Monographs.

Shang, Y. C., & Costa-Pierce, B. A. (1983). Integrated aquaculture-agriculture farming systems: some economic aspects. Journal of the World Mariculture Society, 14(1-4), 523-530.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

TEPHROSIA- A SELF-GENERATING GREEN MANURE CROP

Article ID: AG-V04-I12-95

[1]Lashmipriya, S., [2*]V. Krishnan, V., [1]R. Praveen, [1]K. Preetha, [1]J. Arathi, and [1]S. Aparna

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

Tephrosia purpurea (2n: 24), belonging to sub family Papilionoideae, is a self-regenerating crop and highly drought hardy. Once seeding mostly holds good. It can be used as a green manure in paddy under irrigated as well as in rainfed conditions for other crops as well. It is found in Australia, China, India and Sri Lanka. It is also called as wild Indigo or Kolingi.

BOTANICAL DESCRIPTION OF TEPHROSIA

Habitat: *Tephrosia. purpurea o*ccurs naturally in grassy fields, waste places and thickets, on ridges, and along roadsides and also grows near the seashore. It is found up to an altitude of 400 m. It prefers dry, gravelly or rocky and sandy soils, but in Tamil Nadu it grows well on loamy soils. It is tolerant of saline-sodic soil conditions.

Habit: Erect or spreading annual or short-lived perennial herb, sometimes bushy, 40-80 cm tall, rarely up to 1.5 m; indumentum sericeous, strigose or velutinous.

Root: It has a long stout tap root, many slender branches, erect or decumbent at the base.

Stem: The stems are cylindrical, slender, erect or decumbent and woody at the base, with stiff coarse hairs, frequently reddish in colour.

Leaves: Imparipinnate; stipules narrowly triangular, rachis up to 14.5 cm long, including the petiole of up to 1 cm; petiolule 1-3 mm long; leaflets 5-25, obovate to narrowly elliptical, acute at base, apex rounded to emarginate, venation usually distinct on both surfaces.

Inflorescence: An axillary or leaf-opposed pseudo-raceme, sometimes with basal leaf-like bracts; flowers in fascicles of 4-6; bracts to fascicles.

Flowers: Flowers are papillonaceous, pedicellated, small, solitary or borne in groups of 2, 3 or 4, pink or purple in colour, 6-10 mm in length; bracteoles usually absent; pedicel 2-6 mm long; flower 4-8.5 mm long, purplish to white.

Calyx: Campanulate, persistent, cup shaped, unequally 4-toothed, teeth pubescent inside.

Corolla: Pink to purplish, standard broadly ovate, clawed; wings auricled on vexillary side, clawed; keel auricled on vexillary side, clawed.

Androecium: Stamens 10, staminal tube 4-6 mm long, filaments alternately longer and shorter, free part up to 3.5 mm long, vexillary filament free at base, connate halfway.

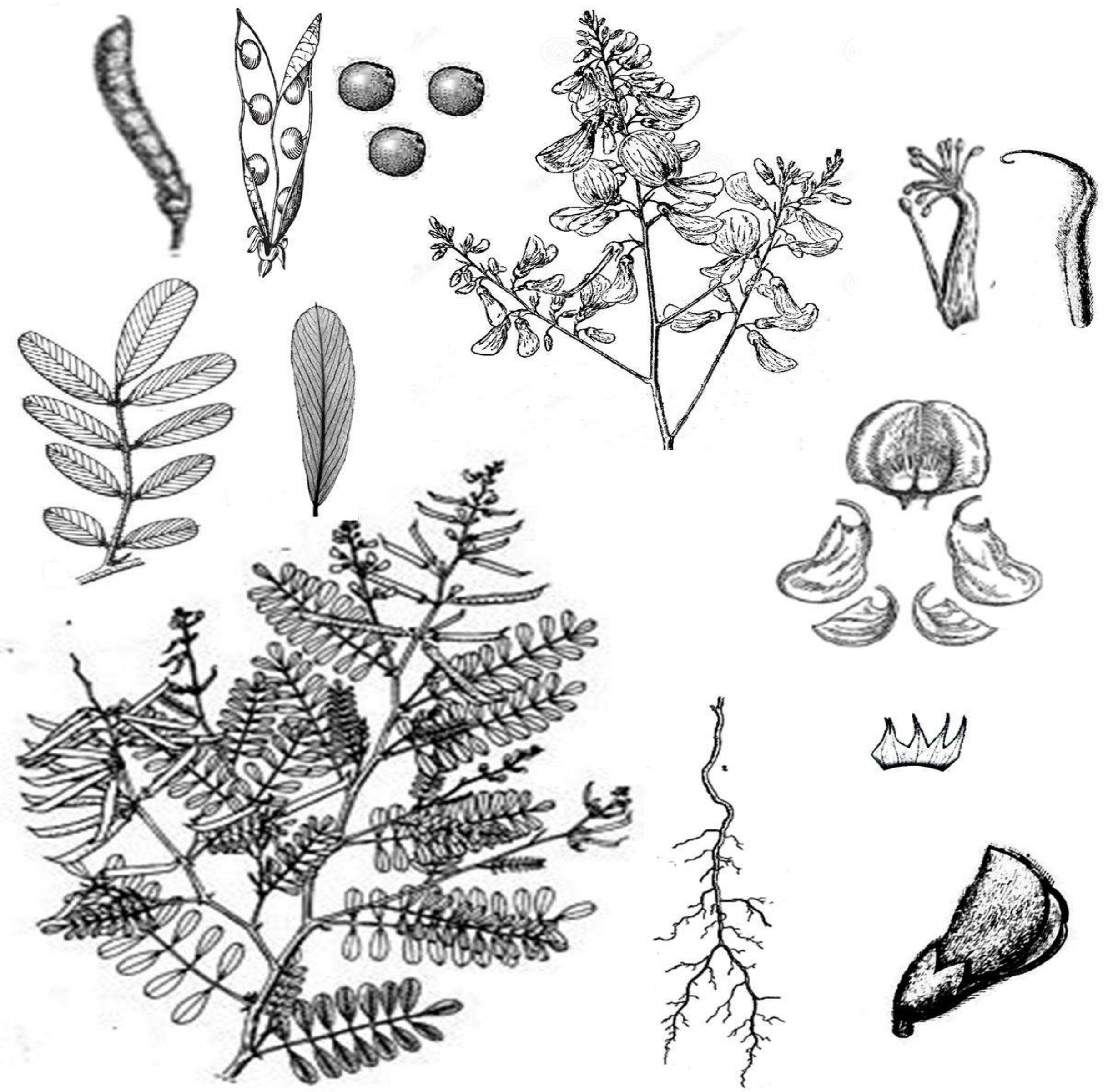


Fig. 1. ***Tephrosia purpurea*****: Botanical illustration**

Gynoecium: Style up to 4.5 mm long, upper half glabrous, stigma penicillate at base.

Fruit: Pod flat, linear, somewhat up-curved towards the end, convex around the seeds, flattened between, margins thickened, dehiscent with twisted valves, 2-10-seeded.

Seed: Rectangular to transversely ellipsoid, light to dark brown to black, sometimes mottled.

Pollination: Cross-pollination by insects.

Center of Origin: Indian Subcontinent and China

Related Species

1. *Tephrosia apollinea*
2. *Tephrosia arenicola*
3. *Tephrosia candida*
3. *Tephrosia chrysophylla*
4. *Tephrosia clementii*
5. *Tephrosia elongata*
6. *Tephrosia glomeruliflora*
7. *Tephrosia mysteriosa*
8. *Tephrosia odorata*
9. *Tephrosia onobrychoides*
10. *Tephrosia piscatoria*
11. *Tephrosia rosea*
12. *Tephrosia socotrana*
13. *Tephrosia spinosa*
14. *Tephrosia villosa*
15. *Tephrosia vogelii*

CULTIVATED TYPES OF TEPHROSIA

1. *Tephrosia purpurea* subsp. *barbigera* var. *balbigera*: Inflorescence and flowers larger, vexillary filaments and staminal tube velutinous occurring in Philippines, New Guinea and Australia.

2. **T*ephrosia purpurea* subsp. *barbigera* var. *rufescens:*:** Inflorescence and flowers medium in size, vexillary filaments and staminal tube, velutinous occuring in Philippines, New Guinea and Australia.

3. ***Tephrosia purpurea* subsp. *purpurea*:** Inflorescence and flowers smaller in size. Vexillary filament and staminal tube glabrous. Commonly found in India, Sri Lanka and South East Asia.

USES OF TEPHROSIA

1. It is used as green manure crop for vegetables, rice, coconut and banana crops.
2. It is also used as a fodder crop before flowering especially for goats in India and Africa.
3. In Northern India, the dried plants are collected for fuel purpose.
4. All plant parts are used as a tonic and laxative in herbal medicine. It is used as a blood purifier in boils and eruptions.
5. The leaves are occasionally used to prepare orange or brown dye and with *Mucuna cyanosperma* (Negro bean) black colour dye is prepared.
6. The seeds are used as a substitute for coffee.
7. It is also cultivated as a temporary shade crop to reduce the soil temperature.
8. It is cultivated in saline and sodic soil to reclaim them from salt injury.
9. In association with Rhizobium it fixes atmospheric nitrogen as nitrates in the soil.
10. It is also associated with Vesicular-Arbuscular Mycorrhizal fungi Glomus heterospoum and Sclerocysis microcarpus to tide over stress environment.
11. Tephrosia is cultivated reclaim Coal and calcite mine spoils.
12. The extract of leaves of Tephrosia act as an antidote for animal bitten by snakes.

GREEN MANURE VALUE OF TEPHROSIA

Tephrosia is grown as an annual crop for green manure purpose. It is the only green manure crop that can be grown both in wetland as well as dryland conditions. It can be grown during summer fallow conditions. It is hardy and drought resistant and suited for summer fallows. It comes up well in loamy soils and could be grown in light soils. The seeds are sown as broadcast in the standing crop of rice just a week before harvest as catch crop. The seeds have a waxy, impermeable hard seed coat and do not quickly germinate. To hasten germination, the seeds are to be pounded with sand or steeped in hot water at 55°C for 2–3 minutes.

Tephrosia can be incorporated into the soil after 60 days and for seed collection 150 days after sowing. The seed rate is 25–40 kg/ha, while the green manure yield varies from 7 to 10 t/ha. The nitrogen accumulation by Tephrosia is around 70 to 115 kg/ha.

Tephrosia purpurea added to the soil as green manure increased humus content and induced the formation of large, stable soil aggregates. Planted on waste sites of coal mines and calcite mine spoils, Tephrosia keeps its nodulating ability and nitrogen fixation. It has been grown in India as a green manure on saline-sodic soils, alleviating soil salinity and lowering the pH.

ADVANTAGES OF TEPHROSIA

1. It is highly suitable for summer fallow conditions.
2. It is self-regenerating and highly drought hardy.
3. It can be grown as green manure crop in irrigated as well as rainfed conditions.
4. It produces ample seeds and builds up a large seed bank in the soil.
5. It reduces salinity as well as sodicity when grown in saline and sodic soils.
6. It can be grown near seashore and therby prevent soil erosion by sea water.
7. It can be grown even in poor degraded soils and make them fertile.
8. Unlike Daincha and Manila Agathi, Tephrosia is an important green manure crop for garden land conditions.
9. They serve as a temporary shade plant to reduce the soil temperature.
10. It is naturally found in marshy fields, waste places, ridges and along the road sides and by collecting them we can use as green leaf manuring for different crops.
11. It can be grown in all seasons and in all types of soils.
12. It is easily decomposed up on incorporation in to the soil.
13. *Tephrosia purpurea* is associated with Rhizobium and form root nodules for nitrogern fixation.
14. Tephrosia is associated with VAM fungi and hence can overcome drought like stress situations easily.

LIMITATIONS OF TEPHROSIA

1. Tephrosia does not tolerate water stagnation.
2. It is a slow growing green manure crop.
3. It is not grazed by cattle and eaten only by goats.
4. Seed yield is only 400 to 500 kg/ha.

5. Becomes a menace as invasive weed species due to its self-regeneration from the seed bank of the soil for succeeding main crop.

6. The seed have a waxy, impermeable hard seed coat and do not quickly. To hasten germination, the seeds are to be abraded with sand or steeped in hot water at 55°C for two to three minutes.

Volume: 04 Issue No: 12

FARM MACHINERY AND EQUIPMENTS OF CUSTOM HIRING CENTERS -BOON TO RURAL AGRICULTURAL FARMERS

Article ID: AG-V04-I12-96

Dr.P.K.Padmanathan*

Associate professor Department of Farm Machinery and Power Engineering

Agricultural Engineering College and Research Institute, TNAU, Coimbatore-3, Tamil Nadu, India

*Corresponding Author Email ID: padmanathanpk@tnau.ac.in

Introduction

Custom hiring of farm machinery was first introduced in Indian agriculture in the 19th century (Srinivasarao et al., 2013). The Government of India launched a scheme in 1971 to establish agro-service centers nationwide further bolstered the growth of custom hiring services. Over the years, the custom hiring service centres have emerged as integral institutions that facilitate the access to modern agricultural machinery, technology, and services for the farming community. The significance of custom hiring service centres (CHSCs) lies in their capacity to bridge the gap between traditional farming methods and contemporary agricultural advancements, fostering sustainable growth and development in the agriculture sector

In India, the level **of** mechanization as of 2015-16 is 40% while the share of the population engaged in agriculture is 40% in 2019-20 and it is estimated to decrease to about26% by 2050. The farm power availability has increased from 1.1 kW/ha in 1995-96 to 2.4 kW/ha in 2015-16. Presently, the National average of farm power availability is 2.02 kW/ha there is a need to increase it to 4.0 kW/ha by 2030 for which custom hiring centers will play a key role.

The average operational land holding size in the country is estimated at 1.16 hectares (ha). About 80% of the land holdings are operated by small and marginal farmers owning < 1 and 1-2 ha holdings, respectively. As per the tenth Agriculture Census, the average size of holdings has shown a steady declining trend over the last three decades. Further, sub-division and fragmentation of the holdings is one of the main causes of low productivity and restricted use of modern farm practices. The small and marginal farmers cannot invest in costly farm machinery and depend on the hiring of implements to carry out agricultural operations in their fields. In rain-fed areas, the window for taking up timely land preparation, sowing and inter-culture operations is narrow, especially in the low rainfall zones. Failing to exploit this limited window often leads to a compromise on productivity and efficiency in crop production. In high-rainfall areas which are dominated by heavy soils, drainage is more crucial to prevent damage to crops from excess soil moisture in the root zone, especially in pulses, oilseeds and cotton. Labour shortage at peak times of demand is a serious problem faced by farmers. Adoption of climate resilient practices such as soil incorporation of legume catch crops and crop residues often leads to a compromise on productivity and efficiency in crop production. Incorporation of legume crops and crop residues to improve soil health and resource conservation technologies are linked to timely access of appropriate farm machinery at a reasonable cost. Several options are now available to increase the efficiency and timeliness of agricultural operations even on small farms by using farm machinery and equipments.

Objectives of Custom Hiring Centres

The objectives of farm machinery custom hiring centres are as follows

1. To offset the adverse economies of scale due to the high cost of individual ownership
2. To improve mechanization in places with low farm power availability
3. To provide hiring services for various agricultural machinery/implements required for different operations
4. To expand mechanized activities during cropping seasons in large areas, especially in small and marginal holdings and
5. To provide hiring services for various high value crop specific machines developed for different operations.

Need of Custom Hiring Centres

The present scenario is a gradual shift of agricultural labour to the industrial sector, which leads to a scarcity of farm labour. During the peak season, the labour force is not available to carried out the farming operations on-time. During the adverse climatic conditions, farmers need immediate action to harvest the crop, in such a condition labour force is the limiting factor. By virtue of their economic condition, small and marginal farmers are unable to purchase farm machinery. *Early harvesting of crop facilities to immediate sowing of next crop. To fulfil the* *above criteria, the availability of farm equipment and machinery to farmers at village level is essential it can be met through Custom hiring centres.*

How Custom Hiring Centre Scheme can help farmers

1. Custom hiring centre supply the farm implements to small, marginal, and poor farmers at subsidized rates on hire.
2. Custom hiring centre enables the small and marginal farmers to take up farm operation on time.
3. Labour scarcity during the peak season is a major problem for farmers and custom hiring centres will fulfil the scarcity of labour.
4. Farm machinery can use during adverse climatic conditions also.
5. Reduction in cost of cultivation and efficiency in use of resources.
6. Provides access to small and marginal farmers to use costly farm machinery.
7. The Custom hiring centre Farm Machinery Mobile App has been launched by the government of India, in which more than 40,000 CHSs have been registered with more than 1,20,000 machinery and equipment will be given on rent.

Advantages of Custom hiring centres

1. Provide access of costly farm machinery to small and marginal farmers \.
2. Promote the adoption of climate-resilient practices and technologies by farmers because of the availability of appropriate machines at reasonable hiring charges
3. Facilitate timeliness in farm operations and efficient use of inputs
4. Reduction in cost of cultivation
5. Promote an increase in cropping intensity wherever feasible
6. Offsets the adverse economies of scale due to the high cost of individual ownership
7. Facilitate crop residue recycling and prevent burning of residues
8. Provide employment opportunities to skilled manpower
9. Provide hiring services for various high-value crop-specific machines developed for different operations.
10. Expand mechanized activities during cropping seasons in large areas, especially in small and marginal holdings and

Social, Economic and Environmental Benefits of Custom Hiring Center

The various economic, social and environmental benefits of the custom hiring services are follows

1. The dependence of farmers on human and bullock labour can be relieved.
2. The economic impact in terms of cost saving, increased yield and increased net returns.
3. Improving safety
4. The use of combined harvesters leads to the expansion of profitable monocrops. Farmers are unable to attain this level of expansion earlier due to the shortage of labour during the peak season.
5. Reduction of harvest and post-harvest losses.
6. Reduction of drudgery and workloads particularly for women.
7. Improves efficiency of production, reduction in cost of production, timely production, increased cultivable area, and crop diversification.
8. Use of the combined harvester takes about 60 minutes to harvest, thresh and pack wheat in an acre of land, which otherwise takes a week time and requires 15 labour days.
9. Generates surplus income through hiring farm-power services to others.
10. Direct and indirect employment generation.
11. Helps in controlling pollution & environment.

CHALLENGES AND OPPORTUNITIES OF CUSTOM HIRING CENTERS

1. The emergence of Custom Hiring Centers offers a plethora of entrepreneurial opportunities. With the right amalgamation of technology, service, and understanding of the agricultural landscape, entrepreneurs can tap into this burgeoning market, delivering solutions that are not just profitable but also socially and environmentally impactful.
2. The establishment of Custom Hiring Centers (CHCs) embodies a notable initiative within the agricultural sector, albeit with its set of challenges and opportunities. The inception of a Custom Hiring Center necessitates a blend of strategic planning, a nuanced comprehension of the local agricultural landscape, and an unwavering commitment to service excellence. Employing a well-orchestrated approach, CHCs possess the potential to evolve into profitable ventures, while simultaneously playing a pivotal role in modernizing agriculture within the region.The evolutionary trajectory of the agricultural sector has witnessed the emergence of Custom Hiring Centers (CHCs) as a quintessential

solution to cater to the mechanization needs of farmers. However, akin to other entrepreneurial ventures, CHCs encapsulate a range of challenges. Entrepreneurs venturing into this domain frequently navigate through a myriad of hurdles, spanning from financial constraints to operational quandaries. This discourse delves into these challenges while proffering innovative solutions, drawing insights from best practices and contemporary research.

3. Financial constraints pose a formidable challenge within the agricultural sector, particularly considering the substantial initial capital requisites for infrastructure, machinery procurement, and operational expenditures. Additionally, the sector is characterized by a fluctuating demand paradigm. This seasonality engenders periods of peak demand for machinery.

Conclusion

Custom Hiring Centers play a crucial role in driving agricultural mechanization and inclusivity in India, marking a significant milestone in the sector's evolution. The widespread establishment of CHCs, supported by government schemes, has underscored their importance in enhancing accessibility to advanced agricultural machinery and fostering entrepreneurial endeavors. Despite the challenges faced, the integration of cutting-edge technologies such as Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT) has paved the way for more streamlined and efficient CHC operations, contributing to sustainable agricultural practices. This integration represents a promising trajectory towards a more resilient and productive agricultural landscape, emphasizing the enduring significance of CHCs in shaping the future of Indian agriculture.

Volume: 04 Issue No: 12

HONEY BEE PASTURAGE

Article ID: AG-VO4-I12-97

***Aruna R[1], K.A. Murugesh[1] And K. Senguttuvan[2]**

[1]Department of Sericulture, Forest College and Research Institute, Mettupalayam – 641 301

[2]Department of Entomology, Tamil Nadu Agricultural University, Coimbatore – 641 003

Tamil Nadu, India

*Corresponding Author Email ID: arunaramaiah07@gmail.com

Introduction

Bee pasturage refers to the availability of flowering plants that provide nectar and pollen for bees. It plays a crucial role in supporting the pollination process, which is essential for the reproduction of many plants, including those that contribute to our food supply. Moreover, bee pasturage is directly linked to honey production, as the quality and quantity of available nectar greatly influence the honey yield. Therefore, understanding and managing bee pasturage is vital for both the health of bee populations and the sustainability of agricultural systems.

Importance of bee pasturage for the ecosystem

Bee pasturage refers to the availability of flowering plants that provide nectar and pollen for bees to feed on. It plays a crucial role in sustaining bee populations and the overall health of ecosystems. Bees are not only important for honey production but also for pollinating a wide variety of plants, including many crops that are vital for human food supply. Without adequate bee pasturage, the decline in bee populations can have detrimental effects on biodiversity and food security.

Types of Bee Pasturage

i) Natural pasturage: wildflowers, meadows, and forests

The place which provides a natural source of nectar and pollen for bees. These areas are rich in diverse plant species that bloom at different times throughout the year, ensuring a continuous supply of nectar and pollen for bees to forage on. Wildflowers, with their vibrant colors and sweet aromas, are particularly attractive to bees and are often found in abundance in natural pasturage areas. Meadows, with their lush grasses and scattered wildflowers, create a perfect foraging ground for bees, allowing them to gather the resources they need to survive and thrive. Forests, too, offer a wealth of pasturage for bees, with their diverse understory plants and towering trees that provide both shelter and food. The natural pasturage provided by these habitats is crucial for supporting healthy bee populations and maintaining the delicate balance of ecosystems. However, as human activities continue to encroach upon natural habitats, the availability of natural pasturage for bees is decreasing at an alarming rate. Deforestation, urbanization, and the use of pesticides in agriculture are all contributing factors to the loss of natural pasturage areas. Without immediate conservation efforts and the restoration of these habitats, the decline in bee populations will only continue to worsen, with devastating consequences for both biodiversity and food security.

ii) Cultivated pasturage: agricultural crops, orchards, and gardens

An alternative source of pasturage for bees is the cultivated areas. These cultivated areas can offer a variety of flowering plants that serve as a valuable food source for bees. However, it is important to note that not all cultivated pasturage is created equal. Monoculture agriculture, which focuses on growing a single crop over large areas, may provide limited floral resources for bees. On the other hand, diversified farming practices that incorporate a variety of crops and plant species can create a more suitable and diverse habitat for bees. By promoting agroecological approaches and encouraging farmers to adopt sustainable farming practices, we can enhance the availability of cultivated pasturage and support bee populations in the face of habitat loss. Additionally, the establishment of community gardens and urban green spaces can also play a crucial role in providing urban bees with access to nutritious forage.

iii) Urban pasturage: parks, rooftop gardens, and green spaces

The newly emerging and trending concepts of miniature gardening provide valuable foraging opportunities for bees in urban environments. These areas can serve as oases amidst the concrete jungle, offering a diverse array of flowering plants that provide nectar and pollen for bees. By designing and maintaining these green spaces with the needs of pollinators in mind, we can create vital corridors for bees to navigate and thrive in urban areas. Parks, with their vast expanses of greenery and carefully curated flower beds, can be transformed into havens for bees. Planting a variety of native flowering plants, such as lavender, sunflowers, and wildflowers, can attract different species of bees and provide them with a rich source of food. Rooftop gardens, on the other hand, offer a unique opportunity to bring nature to the concrete rooftops of buildings. By incorporating pollinator-friendly plants into these spaces, we can create mini-ecosystems that support bee populations and contribute to urban biodiversity.

In addition to parks and rooftop gardens, community gardens also hold great potential in supporting urban bees. These shared spaces not only provide a platform for growing fresh produce but also offer a chance to cultivate plants that are beneficial to pollinators. By encouraging gardeners to include bee-friendly plants in their plots, we can create a network of interconnected green spaces that provide continuous forage throughout the urban landscape.

By prioritizing the establishment and maintenance of urban pasturage, we can ensure that bees have access to nutritious forage even in densely populated areas. These green spaces not only benefit bees but also contribute to the overall health and resilience of urban ecosystems. Through collective efforts, we can create a future where cities are not only concrete jungles but thriving habitats for bees and other pollinators.

Benefits of Bee Pasturage

- Pollination: role in food production and crop yields
- Biodiversity: supporting a diverse range of plant species and wildlife
- Ecosystem services: enhancing soil fertility and water filtration
- Conservation: preserving endangered bee species and promoting ecological balance
- Economic value: contributing to the honey industry and ecotourism opportunities
- Cultural significance: playing a role in traditional practices and folklore surrounding bees
- Climate change resilience: helping to mitigate the effects of climate change through their pollination services.

Strategies for Promoting Bee Pasturage

- Planting native flowering plants: selecting a variety of species that bloom at different times to provide a continuous source of nectar and pollen
- Creating bee-friendly habitats: incorporating nesting sites such as bee hotels, nesting boxes, and undisturbed areas with suitable nesting materials
- Reducing pesticide use: adopting organic farming practices and promoting integrated pest management methods

- Educating the public: raising awareness about the importance of bees and providing resources for individuals to create bee-friendly gardens in their own communities
- Collaborating with local government and organizations: working together to implement policies and initiatives that protect and promote bee pasturage
- Monitoring and research: conducting studies to better understand bee populations, their habitat requirements, and the impact of various factors on their health and survival.
- By prioritizing the preservation and promotion of bee pasturage, we can ensure the survival and well-being of these vital pollinators. With concerted efforts from individuals, communities, and governments, we can create a future where urban landscapes are transformed into thriving ecosystems that support the health and diversity of both bees and humans alike.

Volume: 04 Issue No: 12

FISH OIL: THE HEALTH BENEFITS IN HUMAN AND ANIMAL NUTRITION

Article ID: AG-V04-I12-98

N. Mohana Swapna, K. Bheemeswararao* and R. S. Sravani
Department of Fisheries Resource Management, Andhra Pradesh Fisheries University, Andhra Pradesh, India.
*Corresponding Author Email ID: bheema.bheema.rao@gmail.com

Introduction

Embark on a voyage into the world of fish oil, a renowned dietary supplement enriched with essential omega-3 fatty acids vital for diverse bodily functions. Within fish oil, you'll discover two primary types of these crucial fatty acids: Eicosa Pentaenoic Acid (EPA) and docosahexaenoic acid (DHA). Abundantly present in fatty fishes like salmon, mackerel, and sardines, these nutrients play a pivotal role in supporting overall health and well-being.

The Nutritional Composition of Fish

Fish stands as an affordable and readily available reservoir of animal protein, extending its accessibility even to rural communities. In fish protein content ranging from 18% to 20%, nutrient-rich source that encompasses eight essential amino acids, among them sulfur-containing lysine, methionine, and cysteine. Offering easily digestible protein with high biological value, fish plays a crucial role in supporting the body's growth and development. Notably, fish stands out with lower fat content compared to red meat, making it a wholesome choice for those mindful of their dietary fat intake.

The fat content in fish varies from 0.2% to 25%, with a notable presence of polyunsaturated fatty acids (PUFAs), crucial for growth. These fats not only contribute to energy but also facilitate the absorption of essential vitamins like, A, D, E and K. Fish is particularly rich in bioavailable Vitamin A, essential for normal vision and bone growth. Fatty fish, in particular, surpass lean types in Vitamin A content. Vitamin D, found in fish liver and oils, plays a pivotal role in bone growth by enhancing calcium absorption and metabolism. The steady supply of polyunsaturated fatty acids, especially omega-3 long-chain PUFAs like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), is essential for somatic growth and reproduction, as these fatty acids cannot be synthesized internally.

In marine fishes lipids are generally distinguished by low levels of linoleic acid and linolenic acid and elevated levels of long-chain n3 polyunsaturated fatty acids. Notably, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) stand out as the dominant polyunsaturated fatty acids.

Application of Fish oil in aquaculture

Fish oil is one of the essential feed additives like protein, carbohydrates, vitamins and minerals. Due to its wide nutritional value fish oil finds wide applications across diverse fields including aquaculture i.e. in the formulation and preparing feed.

Beneficial effects of fish oil aquaculture

Its benefits extend significantly to both humans and animals, promoting better growth and development, as well as aiding in improving various health conditions. Fish oil is used as an ingredient in preparation of feed for fishes, shrimp, chickens, pigs, cattle and even pets like dogs.

- Fish oil as an ingredient in aqua feeds helps in strengthening the immune system of animal.
- Improves antimicrobial activity, ant-oxidative effects, and maintain the gut health.
- Reduced mortality in younger animals.
- Improved productivity through better growth and feed conversion, thereby reducing the cost of animal production
- They also improve the reproduction rate in fish which helps in producing high-quality fish.
- It enhances the feed properties like, feed palatability, digestibility and binding capacity etc.
- EPA and DHA in fish oil plays an important role improving cell membrane structure, regulation of inflammation and disease resistance of the animal.

The dietary requirements of the oil can vary between species and within species depending on the stage of life cycle, sex, reproductive status, and environment. higher requirements are needed at a young age. Fish cannot synthesise polyunsaturated fatty acids (PUFA) because they lack the enzymes required to produce them from monounsaturated fatty acids, making them important in the diet. Terrestrial plants can include medium chain PUFAs like linoleic acid and linolenic acid, but the physiologically active fatty acids in fish are long-chain PUFA, primarily EPA and DHA.

Beneficial effects of fish oil in humans

Fish oil supplements come in liquid, capsule, and pill forms. The fish oil capsule, often presented as a single-piece gel capsule or soft gel, is the most widely preferred among these choices. While there isn't a specific prescribed dosage for fish oil intake, there are guidelines for overall omega-3 consumption, including EPA and DHA. The American Heart Association (AHA) advises consuming at least two servings of fatty fish weekly, supplying approximately 500 milligrams (mg) of EPA and DHA combined. For those dealing with heart disease, the AHA recommends higher doses, such as 1,000 mg of EPA and DHA daily, ideally overseen by a healthcare professional.

- **Enhancing cardiovascular well-being:** Research indicates that individuals incorporating fish oil into their diet twice a week or more may experience a lowered risk of heart disease-related mortality. The positive effects of fish oil on the heart include reducing cholesterol levels, lowering triglycerides, managing blood pressure, and hindering the formation of artery-hardening plaques.
- **Lowers high blood pressure:** Several studies indicate slight decreases in blood pressure among individuals using fish oil supplements. Evidence suggests that the positive impacts of fish oil may be more pronounced in individuals with moderate to severe high blood pressure compared to those with mild blood pressure elevation.
- **Reduces triglycerides and cholesterol:** There's strong evidence supports the significant reduction of blood triglyceride levels with the intake of omega-3 fatty acids. Additionally, there seems to be an enhancement in high-density lipoprotein (HDL/good) cholesterol, although an associated increase in low-density lipoprotein (LDL/bad) cholesterol levels has been observed.
- **Rheumatoid arthritis:** Research suggest that incorporating fish oil supplements may contribute to alleviating pain, enhancing morning flexibility, and relieving joint tenderness in individuals with rheumatoid arthritis.
- **Potential for addressing specific mental health concerns:** The brain, devoid of any fluid, comprises roughly 20% polyunsaturated fatty acids, including omega-3. Consequently,

omega-3s play a crucial role in normal brain function. Studies propose that individuals with particular mental health conditions exhibit lower omega-3 blood levels, and increasing omega-3 intake might aid in averting the onset or ameliorating the symptoms of conditions such as depression.

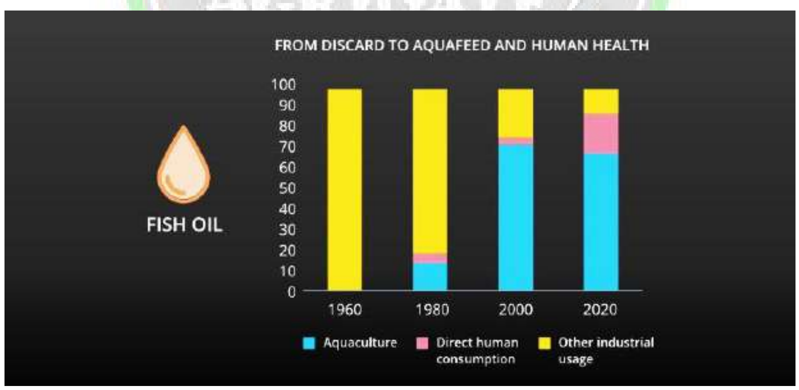
- **Potential for promoting eye health:** Research suggests that individuals with insufficient omega-3 intake face an elevated risk of various eye diseases, excluding dry eye disease. Additionally, as individuals age, there's a natural decline in eye health, potentially leading to age-related macular degeneration (AMD), a condition fish consumption appears to lower the risk of developing.
- **May reduce inflammation:** Due to its anti-inflammatory properties, fish oil is believed to offer relief in managing chronic inflammatory conditions. Situations such as increased weight or stress can occasionally contribute to heightened inflammation, where fish oil might offer support.
- **Promoting skin health:** As the body's largest organ, the skin contains abundant omega-3 fatty acids. Fish oil supplements could potentially offer benefits in managing various skin disorders like psoriasis and dermatitis.
- **Helps in aiding pregnancy and early development:** Omega-3s play a vital role in initial growth, especially in the first trimester of pregnancy and beyond. Incorporating fish oil supplements during pregnancy or while nursing could potentially enhance the child's cognitive and visual development while reducing the risk of allergies.
- **Potential for lowering liver fat:** Fish oil supplements have been shown to enhance liver function and mitigate inflammation, potentially alleviating symptoms associated with non-alcoholic fatty liver disease (NAFLD) and reducing the accumulation of fat in the liver.
- **May improve attention and hyperactivity in children:** Neuro-developmental conditions like attention deficit hyperactivity disorder (ADHD) often manifest as hyperactivity and inattention in children. Fish oil supplements may contribute to improvements in perceived hyperactivity, inattention, impulsiveness, and aggression in children, potentially benefiting early-life learning.
- **Potential for enhancing asthma symptoms and reducing allergy risk:** Asthma, a condition marked by lung inflammation and breathlessness, is increasingly prevalent.

Studies propose that omega-3 may aid in mitigating asthma-related inflammation, lessening symptom severity, and potentially reducing the reliance on asthma medications.

- **Potential for enhancing bone health:** While calcium and vitamin D are crucial for bone health, especially in older individuals, research indicates that omega-3 fatty acids might also offer benefits. Individuals with higher omega-3 intake and blood levels may exhibit improved bone mineral density (BMD).

Global fish oil production

In the year 2024, the global cumulative output of the fish oil production was down by 30% compared to last year. USA and the African countries are the only ones that have registered a positive trend compared to January-March 2023 in fish oil production.



source: IFFO

The global production of fishmeal from by-products accounts for 38%, while fish oil output from by-products represents 55% of the total fish oil production. Fish meal and fish oil were regarded key elements in diets for many carnivorous fish and crustacean species, with global output averaging 6 million tonnes and 1 million tonnes per year, respectively, during this time period. Fish oil consumption peaked somewhat before this, at roughly 0.9 million tonnes per year.

From 1980 to 2020, there was an increasing trend in aquaculture to use fish oil as aquafeed. Currently, fish oil accounts for 70% of aquaculture feed. In recent years, human consumption of fish oil has increased dramatically

Sustainable exploitation of fish oil

Forage or small pelagic fish, fatty or oily fish, and cold-water species, such as trout, mackerel, tuna, herring, sardines, and salmon, are important sources of fish oil production. Increasing fish consumption or using fish oil as a feed ingredient for farm animals may impose pressure fish population.

To alleviate the pressure on fish populations and sustainable production of the fish oil.

- Need to build an ecosystem that easily recover and maintain a balanced biodiversity. A robust biodiversity contributes to more resilient ecosystems that can better withstand environmental stresses.
- Reducing the extraction of fish for oil can help conserve predator species.
- Switching from Fish Oil to other alternative source for essential omega-3 fatty acids. Like Algae Omega-3, is a sustainable alternative that doesn’t deplete marine resources.
- This can contribute to the recovery and sustainability of fish species that are otherwise over-exploited for their oil.

Volume: 04 Issue No: 12

CORAL REEF PLANTS IN GULF OF MANNAR

Article ID: AG-V04-I12-99

S. A. Raj Vasanth*

Department of Aquaculture, Fisheries College and Research Institute,

Thoothukudi-628 008, Tamil Nadu, India

*Corresponding Author Email ID: raaathiraj@gmail.com

Abstract

The Gulf of Mannar, which is situated on India's southeast coast, is well known for its abundant biodiversity, which includes vast coral reefs that are home to a wide range of marine plants. Plants that are linked with coral reefs, like mangroves, seagrasses, and macro algae, are important ecological components in this area. These plants act as primary producers in the food chain, stabilize sediments, and offer habitat for marine life. Important species that flourish in the nutrient-rich and protected environment of the reef ecosystem are *Halophila ovalis* (seagrass) and several genera of red and green algae. However, these essential plants are seriously threatened by human-caused factors like pollution, overfishing, and climate change. To maintain the biodiversity and ecological balance of this special maritime habitat, conservation measures are crucial.

Keywords: Coral Reefs, Wide Range, Marine, Habitat.

Introduction:

The Gulf of Mannar, located between the south-eastern tip of India and the western coast of Sri Lanka, is one of the most biologically diverse marine ecosystems in the world. This region is celebrated for its coral reefs, seagrass meadows, and mangrove forests, which provide critical habitats for a myriad of marine organisms. Among these natural wonders, the coral reef plants and associated flora play an indispensable role in maintaining the ecological balance and supporting the livelihoods of coastal communities.

Coral Reefs and Their Plant Communities:

Coral reefs are often referred to as the "rainforests of the sea" due to their immense biodiversity. The Gulf of Mannar is home to 21 islands with fringing coral reefs, which provide the foundation for a complex web of life. While corals themselves are animals, their symbiotic relationship with photosynthetic algae, known as zooxanthellae, highlights the crucial role of plant-like organisms in reef ecosystems. These microscopic algae live within the tissues of corals, supplying them with energy through photosynthesis and enabling the deposition of calcium carbonate to build reef structures. In addition to zooxanthellae, the Gulf of Mannar's coral reefs support a variety of macroalgae, seagrasses, and mangroves, which collectively contribute to the productivity and resilience of the ecosystem. These plant communities are not only vital for the reef's health but also sustain a wide range of marine life, from herbivorous fish to apex predators.

Macroalgae:

Macroalgae, commonly known as seaweeds, are prominent members of the coral reef flora in the Gulf of Mannar. They are classified into three major groups based on their pigmentation: green algae (Chlorophyta), brown algae (Phaeophyta), and red algae (Rhodophyta). Each group plays a unique role in the reef ecosystem.

Green Algae (Chlorophyta):

Green algae, such as Caulerpa, Halimeda, and Ulva species, are abundant in the Gulf of Mannar. These algae contribute to primary production and serve as food for herbivorous fish and invertebrates. Halimeda, in particular, is significant for its role in calcium carbonate production, which aids in reef-building processes.

Brown Algae (Phaeophyta):

Brown algae, including species of Sargassum and Padina, are commonly found in shallow waters. These algae provide shelter and breeding grounds for various marine organisms. They also play a role in nutrient cycling by assimilating dissolved nutrients from the water.

Red Algae (Rhodophyta):

Red algae, such as Gelidiella and Gracilaria species, are valued for their economic importance as sources of agar and other hydrocolloids. These algae contribute to reef productivity and form a significant part of the diet of many marine species.

Seagrass Meadows:

Seagrass meadows are another critical component of the Gulf of Mannar's marine flora. These submerged flowering plants form dense underwater fields in the sandy and muddy substrates around coral reefs. Common species include Halodule, Halophila, and Thalassia. Seagrasses are highly productive ecosystems that offer numerous ecological benefits:

Habitat and Nursery Grounds: Seagrass beds provide shelter and breeding areas for juvenile fish, crustaceans, and mollusks.

Carbon Sequestration: These plants are efficient at capturing and storing carbon, playing a role in mitigating climate change.

Erosion Control: Seagrass roots stabilize the seabed, reducing erosion and maintaining water clarity.

Food Source: Dugongs (sea cows), green turtles, and other herbivores rely on seagrasses as their primary food source.

Mangrove Forests:

Although mangroves are not directly associated with coral reefs, their proximity to the reef ecosystems in the Gulf of Mannar underscores their importance. Mangroves, such as Rhizophora, Avicennia, and Sonneratia species, grow in the intertidal zones and act as a natural buffer between land and sea. They trap sediments and nutrients, preventing excessive sedimentation on coral reefs, which can be detrimental to corals. Mangroves also serve as a nursery habitat for many marine species that later migrate to coral reefs. The organic matter from mangroves enriches the coastal waters, supporting plankton and other primary producers that form the base of the marine food web.

Ecological Significance of Coral Reef Plants:

Primary Production: Coral reef plants, including macroalgae and seagrasses, are primary producers that convert sunlight into energy, forming the base of the food chain.

Biodiversity Support: These plants provide food, shelter, and breeding grounds for a vast array of marine organisms, including commercially important fish and invertebrates.

Nutrient Cycling: Plants help recycle nutrients within the ecosystem, ensuring the availability of essential elements like nitrogen and phosphorus.

Coastal Protection: Seagrasses and mangroves reduce wave energy and protect shorelines from erosion, safeguarding coastal habitats and human settlements.

Climate Regulation: Seagrass meadows and mangroves act as carbon sinks, absorbing and storing significant amounts of atmospheric carbon dioxide.

Threats to Coral Reef Plants:

Pollution: Agricultural runoff, industrial effluents, and plastic debris degrade water quality, affecting the health of coral reefs and associated flora.

Overfishing and Unsustainable Practices: The overharvesting of seaweeds and destructive fishing methods, such as bottom trawling, disrupt the delicate balance of the ecosystem.

Climate Change: Rising sea temperatures, ocean acidification, and extreme weather events lead to coral bleaching and loss of associated plant species.

Habitat Destruction: Coastal development, dredging, and sand mining result in the loss of mangroves, seagrasses, and reef habitats.

Invasive Species: The introduction of non-native species can outcompete native plants, altering the ecosystem structure and function.

Conservation and Management:

The Gulf of Mannar Biosphere Reserve, established in 1989, is a testament to India's commitment to conserving this unique marine ecosystem. However, effective conservation requires integrated and collaborative efforts:

Marine Protected Areas (MPAs): Expanding and effectively managing MPAs can safeguard critical habitats and allow depleted populations to recover.

Sustainable Harvesting: Regulating the collection of seaweeds and other resources ensures that these practices do not harm the ecosystem.

Pollution Control: Implementing strict regulations to reduce industrial and agricultural runoff can improve water quality.

Community Engagement: Involving local communities in conservation efforts through education and sustainable livelihood programs fosters a sense of stewardship.

Research and Monitoring: Ongoing scientific studies are essential to understand the dynamics of reef ecosystems and the impacts of human activities.

Climate Action: Addressing global climate change through mitigation and adaptation strategies is crucial to protecting coral reefs and their plant communities.

Conclusion

The coral reef plants of the Gulf of Mannar are integral to the health and resilience of this marine ecosystem. From the microscopic zooxanthellae powering coral growth to the expansive seagrass meadows and mangrove forests supporting diverse marine life, these plants form the foundation of a vibrant and interconnected web of life. However, the increasing pressures of human activities and climate change pose significant challenges to their survival. Conservation efforts must be prioritized to protect these invaluable ecosystems. By embracing sustainable practices, enforcing protective measures, and fostering community involvement, we can ensure that the Gulf of Mannar's coral reefs and their plant communities continue to thrive for generations to come. The future of this marine biodiversity hotspot depends on our collective actions today.

References

Edward, J. K. P., Mathews, G., Raj, K. D., Thinesh, T., Patterson, J., Tamelander, J., ... & Hughes, T. P. (2012). Coral reefs of Gulf of Mannar, India: signs of resilience. prevalence, 10, 100.

Maheswari, R. U., Naganathan, V., & Patterson, J. K. (2011). Interrelation among coral reef and sea-grass habitats in the Gulf of Mannar. International Journal of Biodiversity and Conservation, 3(6), 193-205.

Manikandan, S., Ganesapandian, S., Singh, M., & Kumaraguru, A. K. (2011). Seagrass diversity and associated flora and fauna in the coral reef ecosystem of the Gulf of Mannar, Southeast Coast of India. Research Journal of Environmental and Earth Sciences, 3(4), 321-326.

Ramesh, C. H., Prasastha, V. R., Shunmugaraj, T., Karthick, P., Mohanraju, R., Koushik, S., & Murthy, M. V. R. (2023). Diversity and impacts of macroalgae and cyanobacteria on multi-stressed coral reefs in the Gulf of Mannar Marine Biosphere Reserve. Marine Environmental Research, 191, 106161.

Thanikachalam, M., & Ramachandran, S. (2003). Shoreline and coral reef ecosystem changes in Gulf of Mannar, southeast coast of India. Journal of the Indian society of Remote Sensing, 31, 157-173.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

WASTE WATER TREATMENT IN AQUACULTURE

Article ID: AG-VO4-I12-100

S. A. Raj Vasanth*

Department of Aquaculture, Fisheries College and Research Institute,

Thoothukudi-628 008, Tamil Nadu, India

*Corresponding Author Email ID: raaathiraj@gmail.com

Abstract

Aquaculture wastewater treatment is crucial to preserving environmental sustainability and aquatic organism health. If left untreated, the organic matter, phosphorus and nitrogen-rich, and pathogen-rich effluents produced by the aquaculture sector might have a negative effect on nearby ecosystems. Mechanical filtration, biological treatments like bio filters and artificial wetlands, and cutting-edge procedures like membrane bioreactors and electrocoagulation are all effective wastewater treatment technologies. These techniques seek to lessen the environmental impact of aquaculture operations, recycle water, and lower pollution levels. Water quality is improved, resource efficiency is encouraged, and regulatory compliance is supported when waste management techniques are incorporated into sustainable aquaculture systems. To strike a balance between aquaculture productivity and environmental preservation, innovations in wastewater treatment are essential, as are monitoring and management techniques.

Keywords: Management, Environment, Water, Aquaculture.

Introduction

A major contributor to the world's food production is aquaculture, which is the raising of aquatic species like fish, crustaceans, mollusks, and aquatic plants. Aquaculture has become a viable substitute for wild fisheries as the demand for seafood rises. Nonetheless, this sector has difficulties, especially when it comes to controlling the effects of its operations on the environment. Wastewater management is one of the most important of these problems since aquaculture produces a lot of nutrient-rich effluents that can damage aquatic ecosystems.

The Importance of Wastewater Treatment in Aquaculture:

Wastewater from aquaculture operations contains organic matter, nutrients (nitrogen and phosphorus), suspended solids, and potentially harmful chemicals, including antibiotics and pesticides. If discharged untreated, these pollutants can lead to several environmental issues such as eutrophication, oxygen depletion, and the degradation of aquatic habitats. Eutrophication, for instance, results from excessive nutrient loads that stimulate algal blooms, which can disrupt ecosystems and harm aquatic life. Effective wastewater treatment is essential for mitigating these impacts. By reducing nutrient loads and removing contaminants, aquaculture operations can maintain water quality in surrounding ecosystems, comply with environmental regulations, and enhance the sustainability of their practices. Furthermore, treating wastewater enables the recovery of valuable byproducts such as bioenergy and fertilizers, promoting a circular economy within the industry.

Types of Wastewater in Aquaculture:

Aquaculture wastewater can vary depending on the species being farmed, the production system, and management practices. Generally, it includes:

Effluents from Pond-Based Systems: These systems accumulate organic matter, nutrients, and sediments. Discharge typically occurs during water exchange or harvesting, releasing concentrated pollutants.

Effluents from Recirculating Aquaculture Systems (RAS): While RAS minimize water use by recycling it within the system, they generate concentrated waste streams from filtration and sludge removal processes.

Discharge from Flow-Through Systems: In these systems, water flows continuously, carrying away uneaten feed, feces, and other pollutants.

Wastewater from Hatcheries: Hatcheries produce effluents with organic matter, nutrients, and microbial contaminants from larval rearing and feed management.

Methods of Wastewater Treatment in Aquaculture: Wastewater treatment methods in aquaculture can be broadly categorized into physical, biological, and chemical processes. An integrated approach combining these methods often yields the best results.

Physical Treatment Methods: Physical processes involve the removal of solids and sediments from wastewater. Common methods include:

Sedimentation Tanks: These tanks allow suspended solids to settle out of the water under the influence of gravity. The collected sludge can be further treated or used as fertilizer.

Screening: Mesh screens or sieves remove larger particles, such as uneaten feed and feces, from the wastewater.

Filtration: Mechanical or sand filters are used to trap finer particles, improving water clarity.

Biological Treatment Methods: Biological processes utilize microorganisms to break down organic matter and convert nutrients into less harmful forms. Key methods include:

Constructed Wetlands: These systems use aquatic plants and microbial communities to filter and degrade pollutants. Wetlands are cost-effective, environmentally friendly, and provide additional habitat benefits.

Biofilters: These devices house biofilms of beneficial bacteria that metabolize ammonia and nitrites, converting them into less toxic nitrates.

Aerobic and Anaerobic Systems: Aerobic systems, such as activated sludge processes, rely on oxygen-loving bacteria to degrade organic matter. Anaerobic systems, like biogas digesters, break down organic waste in the absence of oxygen, producing methane as a byproduct.

Chemical Treatment Methods:

Chemical processes involve the use of substances to neutralize or remove contaminants. Common techniques include:

Coagulation and Flocculation: Chemicals like alum or ferric chloride are added to aggregate suspended particles into larger clumps, which can be easily removed.

Disinfection: Chlorine, ozone, or ultraviolet (UV) light are used to kill pathogenic microorganisms in wastewater.

pH Adjustment: Acids or bases are added to maintain optimal pH levels for biological processes or to neutralize wastewater before discharge.

Advanced and Emerging Technologies:

Membrane Filtration Technologies:

Membrane systems, such as ultrafiltration and reverse osmosis, offer high-efficiency removal of fine particles and dissolved substances. While costly, they are highly effective for recycling water within recirculating systems.

Integrated Multi-Trophic Aquaculture (IMTA):

IMTA involves cultivating complementary species, such as shellfish and seaweed, alongside fish farming. These species act as natural biofilters, absorbing excess nutrients and improving water quality.

Microalgae-Based Treatment:

Microalgae can be used to assimilate nutrients, particularly nitrogen and phosphorus, from wastewater. In addition to purifying water, this method produces valuable biomass for biofuel, feed, or pharmaceutical applications.

Electrochemical Treatment:

Electrochemical methods, including electrocoagulation and electrooxidation, use electric currents to remove contaminants. These techniques are effective for complex wastewater streams containing metals or organic pollutants.

Challenges in Wastewater Treatment:

Cost Constraints: Implementing and maintaining advanced treatment systems can be expensive, particularly for small-scale operators.

Variable Effluent Quality: The composition of aquaculture wastewater can fluctuate based on species, feed, and farming practices, complicating treatment design.

Environmental Trade-Offs: Some treatment methods, such as chemical processes, may introduce secondary environmental impacts, such as the generation of hazardous sludge.

Regulatory Compliance: Inconsistent enforcement of environmental regulations across regions can hinder the adoption of effective treatment practices.

Future Directions and Sustainability:

Policy and Regulation: Governments should establish clear, enforceable standards for aquaculture effluents and provide incentives for adopting sustainable practices.

Research and Innovation: Investment in research can drive the development of cost-effective and efficient treatment technologies, such as bioreactors and smart monitoring systems.

Capacity Building: Training programs for farmers and operators can improve awareness and implementation of best practices in wastewater management.

Circular Economy Approaches: Promoting the recovery and reuse of nutrients and energy from wastewater can enhance resource efficiency and economic viability.

Conclusion

Wastewater treatment is a cornerstone of sustainable aquaculture. By mitigating the environmental impacts of effluents, effective treatment systems ensure the long-term viability of the industry and the health of aquatic ecosystems. While challenges remain, advancements in technology, supportive policies, and industry collaboration offer promising pathways for improvement. As the aquaculture sector continues to grow, prioritizing wastewater management will be essential for balancing productivity with environmental stewardship.

References

Ahmad, A. L., Chin, J. Y., Harun, M. H. Z. M., & Low, S. C. (2022). Environmental impacts and imperative technologies towards sustainable treatment of aquaculture wastewater: A review. Journal of Water Process Engineering, 46, 102553.

Chatla, D., Padmavathi, P., & Srinu, G. (2020). Wastewater treatment techniques for sustainable aquaculture. Waste management as economic industry towards circular economy, 159-166.

Lin, Y. F., Jing, S. R., Lee, D. Y., & Wang, T. W. (2002). Nutrient removal from aquaculture wastewater using a constructed wetlands system. Aquaculture, 209(1-4), 169-184.

Tom, A. P., Jayakumar, J. S., Biju, M., Somarajan, J., & Ibrahim, M. A. (2021). Aquaculture wastewater treatment technologies and their sustainability: A review. Energy Nexus, 4, 100022.

Volume: 04 Issue No: 12

SIGNIFICANCE OF ENDOSPERM CULTURE

Article ID: AG-VO4-I12-101

[1]Shivada. A., [2*]V. Krishnan., [1]Adavi Lakshmi Nikhil., [1]V. B. Divyadarshini, [1]P. Sowmiya and [1]C. S. Subash Chandra Bose

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

The endosperm is the product of double fertilization, during which out of the two male gametes, one fertilizes the egg to form zygote and other fuses with secondary nuclei to form triploid endosperm. Hence, in diploid plants, the endosperm is a triploid (i.e., having 3 sets of chromosomes). In angiosperms the endosperm is the main nutritive tissue for the embryo. When the endosperm fails to develop properly, abortion of the embryo results. Endosperm may be fully utilized by the developing embryo (non-endospermous), or it may persist in mature seeds (endospermous). The endosperm represents about 60% of the world's food supply. In apomictic species the endosperm develops autonomously, without fertilization of the secondary nucleus. In another apomictic species the endosperm gave rise to triploid embryos.

A further role of the endosperm is to control germination, a process enabling adaption to seasonal changes of the environment.Triploids are usually seed sterile and is undesirable for plants where seeds are commercially useful. However, in cases where seed lessness is employed to improve the quality of fruits as in banana, apple, citrus, grapes, papaya etc. the induction of triploid plants would be of immense use. Triploid plants have more vigorous vegetative growth than their diploid counterparts. Hence, in plants where the vegetative parts are economically useful, triploids are of good use.

History

The traditional method of generating triploids through crossing between colchicine-induced tetraploid (4n) and diploid (2n) plants could take up to 12 years, followed by rescuing the triploid embryos. But in majority of plants, it is not possible and successful, thus endosperm culture was the better and feasible alternative. Endosperm can be used as a nurse tissue for raising hybrid embryos.

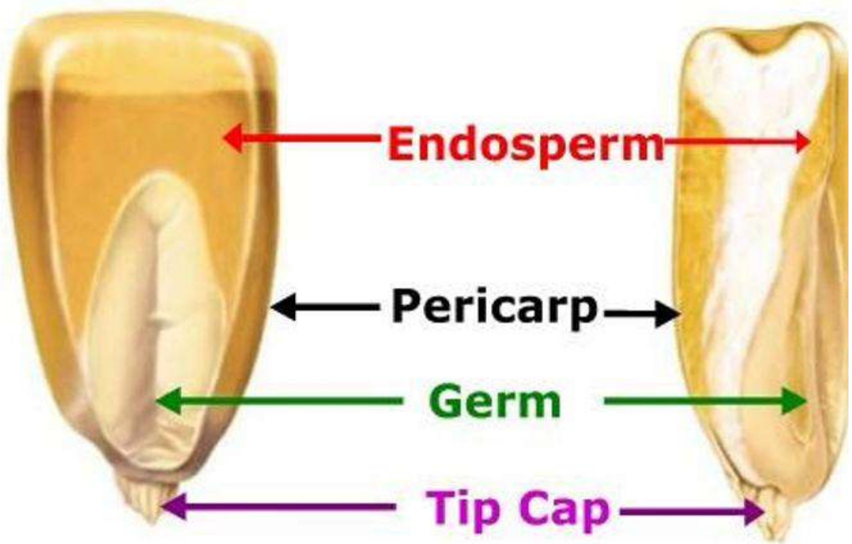


Fig. 1 Different parts of a seed

Attempts to grow endosperm under *in vitro* condition dates back to 1930 by the scientist Lampe and Mills. The young corn endosperm was cultured on the extract of potato and slight proliferation of tissue was noticed from the tissues surrounding the embryo.

In 1947, LaRue, successfully cultured the corn endosperm and obtained plantlets with rootshoot axis and miniature leaves. In maize, the pericarp ruptured & the endosperm exhibited a white tissue mass. This made other workers take up the work on endosperm culture for different species of plants. Since then, several investigators, have cultured the endosperm tissue but invariably have failed to induce organogenesis.

However, successfully organogenesis was achieved from endosperm callus tissue of *Ricinus communis*, *Oryza sativa* and *Pyrus malus.*

- **Wang & Chang** (1978) produced triploid plantlets from ***Citrus.***
- **Laxmi sita** *et al.* (1980) developed triploid plants of ***Santalum album.***
- Presently there are number of crop species (**banana, apple, beet, tea, mulberry**) in which triploids are in commercial use.

ADVANTAGES OF ENDOSPER CULTURE

- The parenchymatous nature of the endosperm and the absence of vascular tissues make it a unique and excellent experimental system for in vitro culture.
- Endosperm culture provides an easy protocol for triploid plant production , endosperm culture is to produce triploids quickly from diploid plants.
- The time needed for triploid plant production is lower than that needed for production using conventional methods.

PROCEDURE

Both mature and immature endosperm used for culture initiation responded differently in cultures. A key factor for the induction of cell divisions in mature endosperm cultures is the initial association of embryo (e.g., mature embryo of *Ricinus communis* on White's medium containing 2,4-D, kinetin, and yeast extract) but immature endosperms proliferate independent of embryo.

The age of the endosperm at the time of culture is critical for its growth. For example, in maize, wheat, and barley, endosperm tissue younger than 8 days or older than 12 days after pollination will not grow in cultures. The endosperm of *Cucumis* can be grown only when excised 4-7 days after pollination. It is a genotype dependent phenomenon. For example, the endosperm of Ricinus communis proliferated 10 days after culture whereas the endosperm of Pyrus malus and Santalum took 15 to 21 days respectively for proliferation

Generally mature endosperm is not a good material for explant since endosperm undergoes some changes after pollination. That is mature endosperm requires the initial association of embryo to form callus but immature endosperm proliferates independent of the embryo, the best explant was immature seeds.

Thus, immediately after a few days of pollination endosperm was selected for this purpose. The entire seed or kernel is surface sterilized and endosperm tissue was excised under sterile conditions. Some of the physical and chemical factors affecting endosperm cultures include pH, light and temperature, sugars, and amino acids. As a carbon energy source, sucrose is commonly used in endosperm tissue cultures. With higher concentrations of sucrose there is generally a decrease in growth.

Selection of a suitable basal medium, addition of proper growth regulators and other adjuvants are the decisive factors that determine the success of triploid plant development. The culture of immature endosperm requires yeast extract (YE), casein hydrolysate (CH), coconut milk (CM), corn extract (CE), potato extract (PE), grape juice (GJ), cow's milk (CWM) or tomato juice (TJ) despite a suitable medium and growth regulator. Murashige and Skoog (1962) basal medium were mostly used to initiate and improve the response in *in vitro* endosperm cultures. White (1963) basal medium (WM) was also employed in some cases.

Most of the immature endosperm culture needs the presence of one or more growth regulators for plant regeneration except Petroselinum, where MS basal medium is sufficient for endosperm embryogenesis. Mainly auxin preferably 2, 4-D is necessary for callus induction. In case of mature endosperm the optimum callus growth was observed either on a cytokinin or a cytokinin in combination with an auxin. In most of the cases the time required to initiate proliferation varies from 10 to 20 days. But a pre-soaking of endosperm with GA3 (5.78 lM) could reduce the time period from 10 to 7 days.

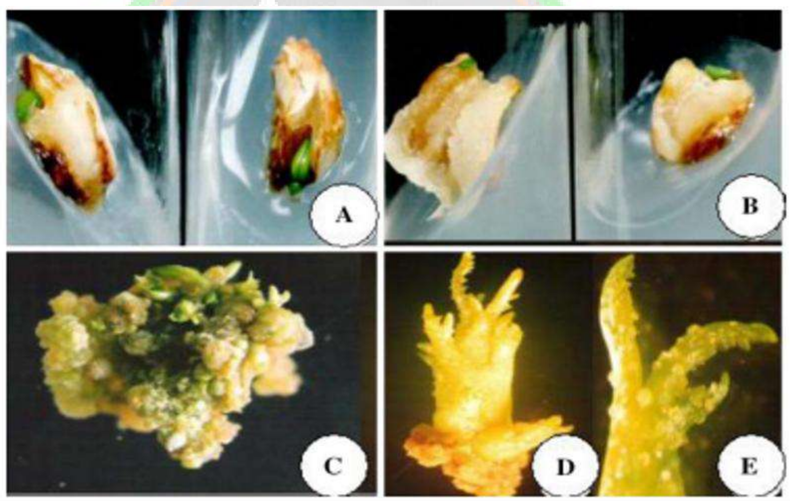


Fig. 2 (a) Immature seeds of *Azadirachta indica* on MS media. After 2 weeks seeds have split open and releasing the green embryos and callused endosperms. (b) White fluffy endosperm calli can be seen from the fully opened seeds after 3 weeks. Green embryos are lying at one end of the explants. (c) 6-week-old subculture of endosperm callus on MS media. (d) 3- week-old culture on MS media showing a healthy elongated shoot. (e) Same as d, enlarged view of shoot tip region showing numerous glands on the surface of leaves.

To produce callus, endosperm culture should be placed in the dark and for organ development bright light is required. In addition, for its function of supplying nutrition to the developing embryo it can also be used for the production of triploid plants. Callus tissue is induced from the endosperm explant in usual manner as with other explant. Presence of organic additives like tomato juice, coconut milk, casein hydrolysate, yeast extract in the culture medium enhanced endosperm proliferation and regeneration.

The initial association of the embryo endosperm for inducing proliferation is that during germination of the embryo, it releases gibberellin - like substances which turn in help in *de novo* synthesis of other enzymes responsible for the endosperm proliferation. These substances are otherwise called `embryo factors'. the embryo factor can be overcome by the use of GA3. The mature endosperms of could proliferate without the association of embryo or pre-soaking of them in GA3. In some cases, the endosperms were cultured along with the embryo and kept in the diffuse light with 16 h photoperiod. Light conditions facilitate the early germination of embryo, which can be removed easily due to their characteristic green colour

Triploids of mulberry

Triploids of mulberry (*Morus sp*.), which are under cultivation in the Northern part of Japan, are known for their superior quality of leaves and disease resistance (Hamada 1963). The triploid plants of tomato produce larger and tastier fruits than natural diploids. The triploid plants of rice (*Oryza sativa*) produced from endosperm showed broader leaves, a faster growth rate, and more of tillering than the normal diploid plant

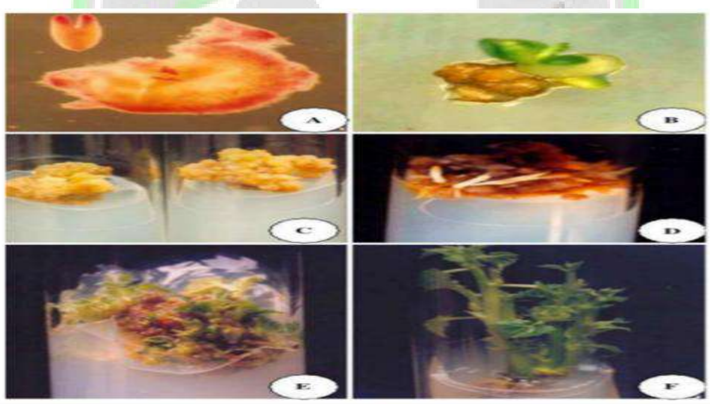


Fig. 3 (a) Endosperm and embryo of *Morus alba.*day, after pollination. The seeds were dissected and stained with safranin. (b) Endosperm cultured along with embryo 7 days after culture on MS medium supplemented with BA (5 lM) and NAA (1 lM). (c) Endosperm derived calli on MS medium supplemented with 2 lM 2, 4-D. (d) Root regeneration from endosperm calli on MS + IBA (1 lM). (e) Regeneration of shoots from endosperm derived calli on MS medium. (f) Multiplication of endosperm derived shoots on MS medium supplemented with 7 lM BA.

Conclusion

Even though callus proliferation from endosperm was possible in several systems, the regeneration of shoots and complete plantlets was possible only to limited number of plants belonging to certain families.

References

Bhojwani SS (1968) Mophogenetic studies on cultured mature endosperm and embryo of some angiosperms. Ph.D. thesis, University of Delhi, Delhi, 85pp

Bhojwani SS, Razdan MK (1996) Plant tissue culture: theory and practice, a revised edition. Elsevier, Amsterdam, pp 1–766

Chakraborty SP, Vijayan K, Roy BN, Qadri SMH (1998) In vitro induction of tetraploidy in mulberry (Morus alba L.). Plant Cell Rep 17:799–803

Chaturvedi R, Razdan MK, Bhojwani SS (2003) An efficient protocol for the production of triploid plants from endosperm callus of neem, *Azadirchta indica* A. Juss. J Plant Physiol 160:557–564

Dwivedi NK, Sikdar AK, Dandin SB, Sastri CR, Jolly MS (1986) Induced tetraploids in mulberry. Morphological anatomical and cytological investigations in cv. RFS 135. Cytologia 51:393–401

Volume: 04 Issue No: 12

MICROPROPAGATION OF GERBERA (*GERBERA JAMESONII* BOLUS)

Article ID: AG-VO4-I12-102

[1]Subash Chandra Bose, C. S., [2*]V. Krishnan., [1]V. B. Divyadarshini, [1]P. Sowmiya, [1]A. Shivada and [1]Adavi Lakshmi Nikhil

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

Gerbera (*Gerbera jamesonii Bolus*), a stunning daisy, belongs to family compositae, widely cultivated both as cut flower and potted plant by the floral industry. Out of 40 known species, only *G. jamesonii* is cultivated. A few of them exhibit outstanding agronomic traits, including stem length, vigor, bloom color, and floral diameter. It is indigenous to Asia and South Africa and has gained commercial significance recently. This plant, often called the Barbeton daisy or Transvaal daisy, bears the name of the German scientist Traugott Gerber. *Gerbera* can be propagated by both sexual and asexual methods. Most of the commercially grown cultivars are propagated through vegetative means, to maintain uniformity and genetic purity. Among the vegetative means, multiplication through divisions of clumps is the most common method used for several decades. Seed propagation, however, is not always satisfactory, since impurity of strain produces a great deal of variation. Gerbera is extremely heterozygous. Multiplication through vegetative propagation by divisions is too slow to be commercially viable. *In vitro* means of propagation is now commercially used to quickly increase cultivar selections for both cut and potted flowering plants and to maintain the uniformity among the cultivars. To commercialize this crop and to meet the growing demand for planting material, tissue and organ culture techniques are being used as alternative methods for propagation in many countries.

Gerbera is being micro-propagated from a variety of explants in different places as a commercial plant. While indirect shoot regeneration has been accomplished using calli produced from various explants, including leaves, petals, and floral buds, direct shoot regeneration utilizing shoot tips as the original explant is the most practical way for bulk multiplication of Gerbera.

Many researchers also support the mechanism of adventitious branch regeneration from floral buds or capitula. In-depth instructions for both direct and indirect Gerbera micropropagation are provided, including how to produce a culture, root it, then harden it and establish it in the field.

Methods used to produce micro-propagated Gerbera:

The micropropagation of Gerbera has been achieved by direct organogenesis from the cultured explants without callusing to avoid variation in the cultures, and by indirect (via callus) methods to induce variations. The surface sterilization of ex vitro explants is crucial and requires utmost care to ensure establishment of healthy cultures. The core micropropagation protocol can be divided into three broad categories. Firstly, selection and establishment of source plants in the glasshouse to ensure the regular availability of explants. Secondly, in vitro establishment of shoot and callus cultures by using suitable concentrations of auxins and cytokinins. Shoots are directly formed and multiplied; induced callus is differentiated in shoot regeneration. Thirdly, root induction followed by period of acclimatization of in vitro plants to ex vitro conditions with gradual reduction in humidity, coupled with reduction in transpiration

Preparation and Sterilization of Culture Media:

In general, high concentration of cytokinin is added in the culture medium for direct shoot regeneration, high auxin concentration is used for callus induction and rooting.

1. Prepare stock solutions of micro- and macro-elements and refrigerate. However, the stock solutions of various plant growth regulators should be prepared fresh at the time of use.

2. Thaw refrigerated stock solutions at room temperature.

3. Add other components such as sucrose and plant growth regulators as required.

4. Add appropriate volume of plant growth regulators from the stock solution of 1 mg/L to give required final concentration.

5. Prepare separate media for (a) direct shoot regeneration (b) callus production (c) shoot regeneration from callus according to the formulation.

6. For direct shoot regeneration from shoot apex, prepare medium containing 1 mg/L kinetin and 1 mg/L BA.

7. For callus induction from petal explants, amend medium with the addition of 2 mg/L 2,4-dichlorophenoxyacetic acid (2,4-D).

8. Prepare medium to induce shoot differentiation on petalderived callus by adding 2 mg/L BA and 0.5 mg/L indole-3- acetic acid (IAA).

9. Add 30 g/L (w/v) sucrose to the medium.

10. Adjust pH of the medium to 5.8 using 1 N HCl or 1 N NaOH solution.

11. Add 0.8% agar (w/v) (Difco-Bacto agar; Loba Chemie, Bombay, India) and dissolve it by boiling.

12. Dispense 25–30 mL medium in 100 mL flasks or 10–15 mL in culture tubes. Plug the flasks or culture tubes with non-absorbent cotton plugs, followed by sterilization in autoclave at 121°C temperature, 15 lb/in 2 steam pressure of 20 min.

13. Store the autoclaved media at room temperature in the dark for 1 week to ensure it is free from contamination.

Plant Source Material and Surface Sterilization

1. Procure the source material from the certified commercial nurseries. Grow them in pots filled with farmyard manure, soil, sand (1:1:1 by volume) in the glasshouse till flowering by regular watering. The sterilization regime should be carried out to establish healthy cultures.
2. Excise shoot apices (0.5–1 cm) and petal explants (2–3 mm) from the mother potted plants.

3. Remove soil and dirt from the explants by washing for 1–2 h under gentle flow of running tap water.
4. Transfer explants to teepol solution (2%, v/v) or Tween-20 and wash with water by vigorous shaking for 30 min.
5. Treat explants with 0.2% fungicide (Carbendazim + Mancozeb solution; 0.2% w/v) prepared by dissolving 200 mg fungicides in 100 mL distilled water for 10–15 min. Keep stirring by using magnetic stirrer. Wash explants thoroughly under running tap water to remove any traces of fungicide from the explants.
6. Treat explants with 0.1% HgCl 2 solution for 2–3 min in laminar hood, and keep shaking. Wash thoroughly with autoclaved double distilled water three to four times in order to remove toxic sterilants.
7. Soak excessive water from explants with autoclaved filter papers.

Culture and Maintenance of Explants:

Different protocols are adopted for direct and indirect shoot regeneration. Autoclaved instruments are used to carry out aseptic manipulations in laminar flow bench.

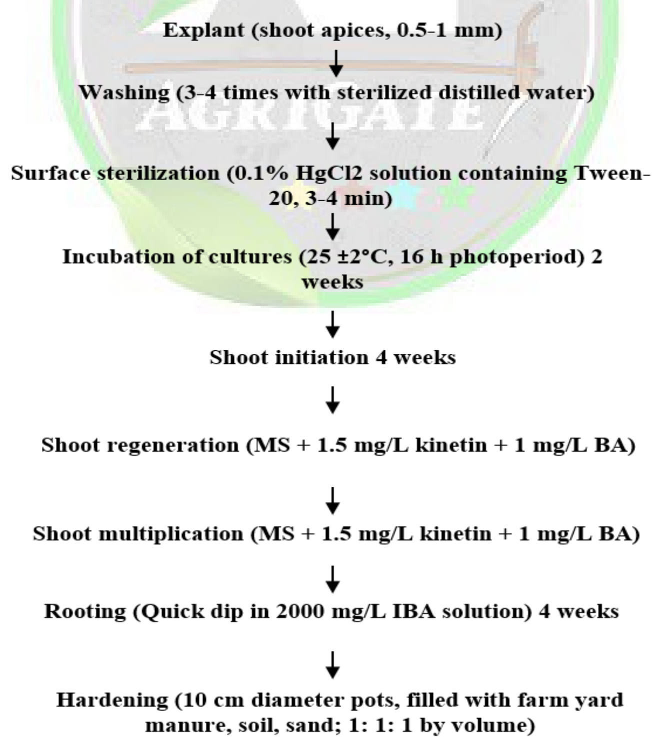


Fig. 1 Flow chart for micro-propagation of Gerbera

For Direct Shoot Regeneration:

1. Uses stem apices (0.5–1 cm) as initial explants.
2. Place one stem apices per culture tube or 3–4 apices in a culture flask, containing MS medium amended with 1 mg/L BA + 1 mg/L kinetin for direct shoot regeneration.
3. Incubate shoot cultures at 25 ± 2°C, 16 h photoperiod (50– 60 mmol/m 2 /s, White cool fluorescent lamp; 40 W, Philips, India).
4. Shoot apices will grow in 2 weeks and become 2 cm long in 4 weeks.
5. When shoots are approximately 2 cm long, separate and multiply them on the same medium. 6. Use 4–5 cm long shoots for root formation.

For Indirect Shoot Regeneration:

1. Use petals for induction of callus.
2. Cut explants into small sections (2–3 mm) and place on the callus induction MS medium, containing 2 mg/L 2,4-D.
3. Incubate cultures in the dark to initiate callus and further growth.
4. Transfer 1-month-old calli, 4–6 mm in diameter, to plant growth chamber, and maintain under 16 h photoperiod, light intensity of 50–60 mmol/m 2 /s.
5. For shoot regeneration, transfer calli on shoot regeneration MS medium containing 2 mg/L BA and 0.5 mg/L IAA.
6. Ideally shoot regeneration starts in 4–5 weeks.
7. Multiply regenerated shoots on the same medium. About 80% explants produced six shoots after 8 weeks.
8. Evaluate the percentage of explants producing callus, callus growth, and type and number of shoots per calli in each case.

Root Development on Regenerated Shoots In Vitro:

1. Select well developed, 4–5 cm long, shoots for root initiation.
2. Quick dip (3–5 s) basal portion of shoots in 2,000 mg/L indole-3-butyric acid (IBA) solution.
3. Some callus may form at the base of shoots prior to rooting. Root system develops in approximately 6 weeks.

Acclimatization of Regenerated Plantlets to Ex Vitro Conditions:

When plants have developed a healthy root system, transfer them to the glasshouse for hardening. Separate shoots and quick dip the individual shoot in IBA solution (2,000 mg/L).

1. Soak the rooted plantlets in fungicide solution (0.2% Carbendazim, w/v) for 1 h.
2. Transfer plantlets to the pots (10 cm diameter) containing farmyard manure, sand, and soil mixed in the ratio 1:1:1 by volume.
3. Water the plants regularly, and cover them with inverted glass jars to maintain high relative humidity (85–90%) at 25 ± 2°C (see Note 16).
4. Shoots are well established within 10–15 days. After 7 days remove jars for few hours per day to facilitate acclimatization of plants in ex vitro condition.
5. After 1 month, remove jars and transfer plants (4–5 cm long with 5–6 leaves) to the glasshouse and expose gradually to the *ex-vitro* conditions.

Conscientious:

1. Establishment of in vitro cultures of Gerbera can be difficult because of frequent contamination of initial explants.
2. Stock solutions of plant growth regulators should be prepared separately. Ensure that MS stocks are free from contamination at the time of use.
3. Media should be autoclaved properly and stored for 1 week prior to use, to ensure that it is free from microbial contamination.
4. Use young and juvenile plant parts because older parts develop wax layers and produce phenolic compounds.
5. Whenever surface fungicides fail to prevent contamination of cultures, use systemic fungicides (Carbendazim + Mancozeb).
6. Treatment time of explants with sterilizing agent should be monitored carefully. Too long or too short treatments of sterilization will result in browning or contamination of explants, respectively.
7. Ethanol, sodium oxychloride, and commercial bleach are effective sterilant.
8. Wash explants thoroughly during each step of surface sterilization to remove any traces of toxic sterilizing agent sticking to the explants. Gloves should be used while handling mercuric chloride solution.

9. Shoot regeneration from stem apices is highly genotype specific. The present protocol is effective for most of the local cultivars.
10. Dedifferentiation from the callus is a slow process and takes 3–4 months. Subculture callus to fresh culture medium every 4 weeks.
11. The best shoot regeneration from callus has been obtained with different concentrations of BA, however, the number of shoots per callus varied with the change in BA concentration.
12. IBA is most effective for root induction in Gerbera.
13. Remove dead or broken lateral roots prior to transfer to the potting mixture.
14. It is recommended to cut very long roots; 3–4 cm long roots are preferred for transferring to the soil. 15. Perlite, sphagnum, peat, sand, cocopeat, and farmyard manure, mixed in different ratios, are effective for ex vitro acclimatization of Gerbera. 16. It is mandatory to maintain 85–90% relative humidity around the plants during the first 10–15 days of transfer to pots.

Types of explants used for culture by various workers:

Pierik and Segers (1973) reported adventitious root formation and callus induction from in vitro culture of mid-rib explants of Gerbera. Murashige proposed a tissue culture method for rapid clonal multiplication of *Gerbera jamesonii* by using shoot tips as initial explants. Pierik *et al*., 1974 reported the development of shoots from dormant buds situated in the axils of bracts surrounding the receptacle of the flower capitulum. Pierik *et al.* 1975 excised capitulum explants from a red flowered *Gerbera jamesonii* clone and forced them to develop shoots. Gregorini *et al*. 1976 propagated gerbera by in vitro culture of vegetative apices. Pawlowska 1977 used inflorescence buds of gerbera as initial explants, Hasbullah used leaves of gerbera as the explants for production of shoots. Pierik et al., 1982 studied effects of cytokinin on shoot formation of *Gerbera jamesonii* in vitro using capitulum as explants. (12) reported the in vitro formation of gerbera plantlets through scape culture in four cultivars of gerbera. Vieth et al., 1963 reported in vitro plantlet production from young capitulum explants of *Gerbera jamesonii*. Petru et al., 1984 produced in vitro cultures of gerbera (*Gerbera jamesonii* Bolus) using shoot tips and young flower buds as explants. Schum et al. 1985 concluded that in vitro shoot production of 17 *Gerbera jamesonii* cultivars was higher from 1 to 2 cm long flower bud explants. Laliberte et al. 1985 studied in vitro propagation of two clones of *Gerbera jamesonii* from fragments of young capitulum, 0.5 to 0.7 cm in diameter as explants. Huang et al. 1985 reported a scheme for commercial multiplication of gerbera (Gerbera hybrid Hort.) through shoot tip culture Huang et al., 1987 proved clonal propagation using capitulum explants of several *Gerbera jamesonii* hybrids to be successful. Dillen et al. 1988 cultured capitula of white, orange and yellow gerbera cultivars as explants. Arello et al. 1991used capitulum explants for in vitro establishment and seedling regeneration in *Gerbera jamesonii* Bolus ex Hook by tissue culture. Ruffoni et al. 1991 used leaf, petiole and apex explants of *Gerbera jamesonii* to establish tissue and cell cultures. Jerzy et al. 1991 used leaf sections of gerbera as initial explants. Reynoird et al. 1993 concluded that efficient bud regeneration can be obtained from a clone of gerbera hybrid by using leaf explants for culturing on modified Murashige and Skoog (MS) medium. Barbosa et al. 1993 studied effects of BAP and IAA on in vitro propagation of *Gerbera jamesonii Bolus* ex Hook cultivar 'Appelblosem' by culturing leaf bud explants. Barbosa et al. 1994 reported in vitro propagation of *Gerbera jamesonii* using young capitulum explants. Constantinovici et al. 1995 established a method for regenerating gerbera plantlets in vitro by us flower meristems and vegetative apices. Parthasarathy et al. 1997 used explants from fully expanded leaves of in vitro grown seedlings of *Gerbera jamesonii* for culturing.

Conclusion

It can be cultivated throughout the year. Though it is cultivated in the field condition, production of quality flowers require green shade house or ventilated polyhouse. Traditionally multiplication is done to seeds or rhizome cuttings. For rapid multiplication of quality cultivar, it is propagated through division of suckers and tissue culture plants. Gerbera requires are easier, quicker, and economically viable method of propagation. Micropropagation method has been successfully used for rapid, large-scale multiplication of Gerbera. Micropropagation of Gerbera is being used in many countries from a range of explant direct shoot regeneration using shoot tips as initial explant is most convenient method for mass propagation of Gerbera. However, indirect shoot regeneration is also followed.

References

Arello, E. F., Pasqual, M., Pinto, J. E. P. B. and Barbosa, M. H. P. (1991). *In vitro* establishment of explants and seedling regeneration in *Gerbera jamesonii* Bolus ex Hook by tissue culture. *Pesquisa Agropecuaria Brasiteira*, 26(2): 269-273.

Barbosa, M. H. P., Pasqual, M., Pinto, J. E. B. P. and Arello, E. F. (1993). Effect of benzyl arnino purine and indole-3-acetic acid on *in vitro* propagation of *Gerbera jamesonii* Bolus ex Hook cultivar Appelbloesem. *Pesquisa Azropecuaria Brasileira*, 28(1): 15-19.

Barbosa, M. H. P., Pinto, J. E. B. P., Pinto, C. A. B. P. and Innecco, R. (1994). *In vitro* propagation of *Gerbera jamesonii* Bolus ex Hook cultivar Appelbloesem using young capitulums. *Revista Ceres*, 41: 386-395.

Constantinovici, D. and Sandu, C. (1995). Studies on the regenerative capacity of different gerbera explants for effective *in vitro* multiplication. *Cercetari Agronomice in Moldova*, 28(3-4): 149-152.

Dillen, W. and Topoonyanont, N. (1988). Capitulum explants as a start for micro propagation of *Gerbera* culture technique and applicability. *Meded. Fac. Landbouwwet. Rijksuniv. Gent.*, 53(1):169- 173.

Gregorini, G., Lorenzi, R. and Lancioni, G. (1976). The propagation of gerbera by *in vitro* culture of vegetative apices. *Rivista delta Orioflorofrutticoliura Italuma*, 60(5): 282-288.

Hasbullah, N. A., Taha, R. M. and Awal, A. (2008). Growth optimization and organogenesis of *Gerbera jamesonii* Bolus ex. Hook *in vitro*. *Pakistan Journal of Biological Sciences*, 11(11). 1449-1454.

Huang, J. M., Ni, Y. Y. and Lin, M. H. (1987). The micro propagation of gerbera. *Acta Horticulturae. Sinica*, 14(2): 125-128.

Huang, M. C. and Chu, C. Y. (1985). A scheme for commercial multiplication of gerbera (*Gerbera hybrida* Hort.) through shoot tip culture. *Journal of the Japanese Society for Horticultural Science*, 54(1): 94- 100.

Jerzy, M. and Lubomski. (1991). Adventitious shoot formation on *ex vitro* derived leaf explants of *Gerbera jamesonii*. *Scientia Horticulturae*, 47: 115-124.

Laliberte, S., Chretien, L. and Vieth, J. (1985). *In vitro* plantlet production from young capitulum explants of *Gerbera jamesonii*. *Hort Science*, 20(1): 137-139.

Murashige, T., Serpa, M. and Jones, J. B. (1974). Clonal multiplication of gerbera through tissue culture. *Hort Science*, 9(3): 175-180.

Parthasarathy, V. A., Parthaarthy, U., Nagaraju, V. and Mishra, M. (1997). Callus induction and subsequent plant regeneration from leaf explants of *Gerbera jamesonii*. *Folia Horticulturae*, 9(2): 83-86.

Pawlowska, H. (1977). Trials on gerbera propagation *in vitro. Hod. Rosl. Aklimat.* Nasienn, 21(2): 177-181.

Petru, F. and Matous, J. (1984). *In vitro* cultures of gerbera *(Gerbera jamesonii* Bolus). *Shornik UVTIZ Zahradnictvi*, 11(4): 309-311.

Pierik, R. L. M. and Segers, T. A. (1973). *In vitro* culture of midrib explants of gerbera: Adventitious root formation and callus induction. *Zeitschrift fur Pflanzonptrysiologie*, 69(3): 204-212.

Pierik, R. L. M., Verhaegh, J. A. M. and Walters, A, N. (1982). Effect of cytokinin and cultivar on shoot formation of *Gerbera jamesonii in vitro. Netherlands Journal of Agriculture Science*, 30(4): 341 -346.

Pierik, R.L.M., Jansen, J.L. M. and Maasdam, A. (1974). Vegetative propagation of gerberas in test tubes. *Vakbladvoov de Bloemisteri, 29(39): 18-19.*

Pierik, R.L.M., Jansen, J.L.M., Maasdam,A. and Binnendijk, C.M.*(*1975). Optimization of gerbera plantlet production from excised capitulum explants. *Scientia Horticulturae*, 3: 351-357.

Reynoird, J. P., Chriqui, D., Noin, M., Brown, S. and Marie, D. *(*1993). Plant regeneration from *in vitro* leaf culture of several *Gerbera* species. *Plant Cell Tissue and Organ Culture*, 33(2): 203-210.

Ruffoni, B. and Massabo, F. (1991). Tissue culture in *Gerbera jamesonii* hybrida. *Acta Horticulturae*, 289:147-148.

Schum, A. and Busold, M. (1985). *In vitro* shoot production from inflorescence of Gerbera. *Gartenerborse and Gartenwelt*, 85 (47): 1744-1746.

Vieth, J., Morissel, C. and Lamond, M. (1983). Current studies on *Gerbera jamesonii* in the laboratory of *in vitro* culture of the Botany Institute. *Rev. Can. Biol. Exp*., 42(3): 308.

Volume: 04 Issue No: 12

ORGANIC AND VEGAN PRODUCTS: OPPORTUNITIES FOR INDIAN TRADITIONAL FOOD IN GLOBAL MARKETS

Article ID: AG-VO4-I12-103

Dr.F.G.Sayyad[1], Dr.J.Sravankumar[2] and Dr.S.S.Chinchorkar[3]

[1] Scientist, Agricultural Engineering, KVK, AAU, Dahod, Gujarat, India

[2]Assistant Professor, CAET, AAU, Godhra, Gujarat, India

[3] Assistant Professor, PAE, AAU, Dahod, Gujarat, India

*Corresponding Author Email ID: faridape@aau.in

Abstract

The increasing global awareness of health, sustainability, and ethical consumption has fueled a surge in demand for organic and vegan food products. Indian traditional food products, characterized by their rich heritage and health benefits, align well with this trend. Organic grains, lentils, spices, and plant-based dairy alternatives like almond milk represent significant opportunities for Indian producers in international markets. This article explores the growth drivers, challenges, and strategies for tapping into the global demand for organic and vegan products, with a focus on Indian traditional food items.

Keyword: Organic food, Vegan products, Indian traditional food, Plant-based dairy alternatives, Ethical consumerism, Superfood, Sustainable consumption, Vegan dietary trends

Introduction

The global food industry is witnessing a paradigm shift as consumers increasingly prefer organic and vegan options for their health, environmental, and ethical benefits. India, with its vast repository of traditional, plant-based, and minimally processed food products, is uniquely positioned to cater to this demand. Indian organic grains, lentils, spices, and innovative dairy alternatives have already begun to find favor in international markets. However, to leverage this opportunity fully, a deeper understanding of market dynamics and strategic interventions is required.

Global Trends in Organic and Vegan Consumption

1. **Health Consciousness:** Rising awareness about the health impacts of artificial ingredients and processed foods has driven the demand for organic and vegan options.
2. **Environmental Sustainability:** Consumers are choosing plant-based products for their lower carbon footprint compared to animal-derived foods.
3. **Ethical Consumerism:** Veganism is gaining popularity due to ethical concerns about animal welfare.

These trends have created a robust market for organic and vegan food, with projections indicating a compound annual growth rate (CAGR) of 9.7% for the global organic food market and 10.6% for the vegan market by 2030.

Indian Traditional Food Products in the Organic and Vegan Space

1. Organic Grains and Lentils

Popular Products: Rice (including Basmati and Red Rice), Wheat, Millets, Chickpeas, and Moong Dal.

Export Markets: The USA, Europe, and the Middle East are major importers of Indian organic grains and lentils.

2. Spices

Key Products: Turmeric, Cumin, Cardamom, and Coriander.

Advantages: Indian spices are known for their medicinal properties and rich flavors. Organic certification enhances their appeal in global markets.

3. Plant-Based Dairy Alternatives

Emerging Products: Almond milk, Coconut milk, Soy milk, and Cashew-based products.

Growth Drivers: Increasing lactose intolerance and vegan dietary preferences among global consumers.

Challenges in Exporting Indian Organic and Vegan Products

1. **Regulatory Barriers:** Varying organic certification standards across countries.
2. **Supply Chain Inefficiencies:** Lack of cold chain infrastructure and logistics challenges for perishable items.
3. **Market Awareness:** Limited marketing efforts to highlight the uniqueness of Indian traditional organic and vegan products.

Strategies to Enhance Global Reach

1. **Streamlining Certifications:** Aligning Indian organic certification standards (like NPOP) with international standards such as USDA Organic and EU Organic.
2. **Branding and Marketing:** Highlighting the health benefits, cultural heritage, and sustainability of Indian traditional foods through digital marketing and storytelling.
3. **R&D and Innovation:** Developing new plant-based alternatives and ready-to-eat organic food products tailored to global tastes.
4. **Collaborations:** Partnering with international distributors and retailers to improve market access.

Case Studies Research

1. **Turmeric Success Story:** Indian turmeric exports have surged due to its recognition as a superfood with immunity-boosting properties. Organic turmeric with curcumin labeling has seen particularly high demand.
2. **Vegan Dairy Alternative Growth:** Startups like *Epigamia* and *Urban Platter* have successfully introduced almond milk and other plant-based products in international markets.

Conclusion

The global demand for organic and vegan food products present a lucrative opportunity for Indian traditional food producers. By overcoming regulatory and logistical challenges and adopting targeted marketing strategies, Indian organic grains, lentils, spices, and plant-based dairy alternatives can become staples in international markets. This will not only boost export revenues but also promote sustainable and ethical consumption practices worldwide.

Reference

1. Food and Agriculture Organization (FAO) Reports on Organic Agriculture.
2. Market Research Reports on Vegan and Organic Food Markets (2024).
3. Export Promotion Council Reports, Government of India.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

PHYSICS-DRIVEN SOLUTIONS FOR SUSTAINABLE AGRICULTURE: INNOVATIONS IN AGRICULTURAL ENGINEERING

Article ID: AG-VO4-I12-104

***Dr. S.S. Chinchorkar[1] and Dr. F.G. Sayyad[2]**

[1]Assistant Professor, PAE, AAU, Dahod, Gujarat, India

[2] Scientist, Agricultural Engineering, KVK, AAU, Dahod, Gujarat, India

*Corresponding Author Email ID: csachin.chinchorkar@gmail.com

Abstract

The integration of modern physics into agricultural engineering has revolutionized the way agricultural processes are managed and optimized. This research explores the application of various principles of physics, such as electromagnetic fields, laser technology, nanotechnology, and renewable energy systems, in the development of advanced agricultural technologies. The study emphasizes how these technologies improve crop yields, water and resource management, and environmental sustainability. By focusing on key innovations such as precision irrigation, mechanized farming, and renewable energy solutions, this paper highlights the significant role that modern physics plays in addressing the challenges faced by the agricultural sector. Through the use of theoretical and applied physics, these advancements offer promising solutions for sustainable agricultural practices and food security.

Keywords: Modern Physics, Precision Agriculture, Laser Technology, Nanotechnology, Sustainable Farming, Environmental Sustainability.

Introduction

Modern physics has become an essential component in various fields of engineering, including agricultural engineering. The application of principles from physics has led to innovative solutions that address challenges in agriculture, enhance productivity, and promote sustainability. This research explores the use of modern physics in agricultural engineering, focusing on technologies that improve crop yields, resource management, and environmental sustainability.

1. Electromagnetic Fields and Irrigation Systems

One of the most significant contributions of modern physics to agricultural engineering is the application of electromagnetic fields in irrigation systems. By using sensors and electromagnetic waves, scientists and engineers have developed more efficient irrigation systems. The use of electromagnetic induction to measure soil moisture content allows for precision irrigation, reducing water wastage and ensuring optimal growth conditions for crops. This technique minimizes water usage while maximizing crop yields, contributing to the sustainability of agricultural practices.

2. Laser Technology in Agriculture

Lasers, a product of advancements in optics and quantum physics, are now used in precision agriculture. Laser technology is applied in soil testing, crop monitoring, and weed control. Laser sensors can measure crop height, detect early signs of disease, and evaluate soil composition. In weed control, lasers are used to target and eliminate weeds in a more environmentally friendly way compared to traditional herbicides. This technique reduces chemical use, which is beneficial for both the environment and human health.

3. Mechanization and Robotics

Physics plays a crucial role in agricultural machinery and robotics. Advanced concepts in mechanics, dynamics, and control systems have led to the development of autonomous tractors, harvesters, and drones. These machines use principles of physics to navigate fields, assess crop conditions, and perform tasks with high precision. The application of robotics has resulted in labor-saving devices that increase efficiency and reduce the cost of manual labor. Drones equipped with cameras and sensors provide real-time data on crop health, pest infestations, and irrigation needs, making it easier to manage large agricultural operations.

4. Renewable Energy in Agricultural Operations

The integration of renewable energy sources into agricultural engineering is also heavily influenced by modern physics. Solar, wind, and hydroelectric power systems are used to provide sustainable energy solutions for rural farming communities. Solar-powered pumps, wind turbines, and biogas plants are examples of energy systems that reduce farmers' dependence on fossil fuels. Physics concepts such as thermodynamics and energy transfer are essential in designing and optimizing these systems to ensure maximum energy efficiency in agricultural operations.

5. Nanotechnology and Precision Agriculture

Nanotechnology, based on principles of quantum mechanics and material science, is making a significant impact on agricultural engineering. In precision agriculture, nanomaterials and nanoparticles are used to develop fertilizers and pesticides that are more efficient and targeted. Nanotechnology also plays a role in sensors and data collection devices that monitor soil and crop conditions at a microscopic level. This technology allows farmers to apply resources such as water, fertilizers, and pesticides only where needed, reducing waste and improving environmental outcomes.

6. Environmental Monitoring and Climate Change Mitigation

Modern physics techniques, including remote sensing, data modeling, and climate simulation, are used in agricultural engineering to assess the impact of climate change on farming. Satellite imagery and sensors provide valuable data on soil moisture, temperature, and other environmental factors. This information is used to predict weather patterns, track climate change, and adjust agricultural practices accordingly. Understanding the physics of climate systems is essential for developing strategies to mitigate the effects of extreme weather events, such as droughts, floods, and temperature fluctuations, on agricultural productivity.

7. Food Processing and Preservation

Physics also plays a critical role in food engineering, particularly in food preservation techniques. The use of refrigeration, freezing, and heat treatment processes in food preservation is based on principles of thermodynamics and heat transfer. Advances in food packaging technologies, such as vacuum sealing and modified atmosphere packaging, also rely on understanding the physical properties of gases and materials. These technologies help extend the shelf life of agricultural products, reduce food waste, and improve food safety.

Conclusion

The integration of modern physics into agricultural engineering has led to significant innovations that enhance the efficiency, sustainability, and productivity of agricultural practices. Technologies like precision irrigation, laser sensors, robotics, renewable energy systems, and nanotechnology are transforming the way we produce and manage food. As agricultural challenges continue to grow in the face of climate change and population growth, the role of modern physics will only become more crucial in shaping the future of agricultural engineering. The continued collaboration between physicists and agricultural engineers will undoubtedly lead to further breakthroughs that will help address the world's food security and sustainability challenges.

References

Tewari, H., & Yadav, A. K. (2020). *Applications of Laser Technology in Agriculture: A Review*. Journal of Agricultural Engineering, 37(4), 112-121.

Singh, R., & Kumar, P. (2019). *Nanotechnology and its Role in Sustainable Agricultural Practices*. Renewable Agriculture and Food Systems, 34(2), 200-210.

Sharma, V., & Soni, A. (2021). *Solar-Powered Irrigation Systems: A Viable Solution for Sustainable Agriculture*. Journal of Sustainable Agriculture, 45(1), 35-44.

Kumar, S., & Gupta, R. (2018). *Precision Agriculture: Integrating Physics-Based Technologies for Increased Productivity*. Agricultural Engineering Today, 40(5), 58-67.

Patel, M. S., & Rao, S. (2022). *Role of Renewable Energy in Agricultural Mechanization*. Energy for Sustainable Development, 32(3), 89-95.

Peters, R., & Kessler, H. (2017). *Emerging Trends in Agricultural Robotics: Physics and Mechanization*. Robotics in Agriculture, 15(3), 177-186.

Ravindran, S., & Kumar, S. (2023). *Electromagnetic Induction-Based Irrigation Management Systems: Benefits and Challenges*. Journal of Environmental Engineering, 52(8), 1021-1030.

Volume: 04 Issue No: 12

DIRECT SEEDED RICE – CHALLENGES AND OPPORTUNITIES

Article ID: AG-V04-I12-105

S.R. Mythili*, Nivetha K.R., M. Umadevi, R. Suresh and S. Manonmani
Department of Rice, Tamil Nadu Agricultural University, Coimbatore – 641003, Tamil Nadu, India
Corresponding Author Email ID: mythu71096@gmail.com

Introduction

Rice (*Oryza sativa* L.) belonging to the family Poaceae is one of the top most-produced commodities in the world. As of the year 2022, the area harvested under rice in the world is 165 million ha. Average world rice production is 776 million tonnes. Among this, Asia contributes to the vast production of rice about 90.5% of the total share. In India, during the Kharif season, almost 55% of the total cultivated area (39.54 million hectares) is dedicated to paddy production, as per the Government of India report (GOI) in 2022. Rice is cultivated under different ecosystems such as irrigated, rainfed lowland, flood-prone, upland rice, etc. The area under irrigated rice is 25.12 mha which is 58% of the total rice area of 42.75 m ha. The transplanted rice requires an irrigation input of about 1000 to 2000 mm depending upon the climate, soil type and hydrological conditions. For producing 1kg of rough rice, it requires about 2500 litres of water. This shows that an irrigated system of rice cultivation is more labour, water and energy. It is alarming that these resources are becoming increasingly scarce.

Direct seeding methods such as wet seeding and dry seeding, aerobic system of rice cultivation are the alternatives to the transplanted system of rice cultivation to use the resources efficiently. Direct-seeded rice (DSR) is a potential water-saving technology for paddy production, which cuts land preparation time, involves direct sowing, and minimizes irrigation water requirements and soil greenhouse gas emissions. In recent years, Direct Seeded Rice (DSR) cultivation is being followed in many countries across the world such as the United States, Australia, Srilanka, Malaysia, Vietnam and Southeast Asian countries owing to the lack of labour and water resources. Direct seeding in rice offers several benefits to the farmers by saving the water and labour resources by 60 and 40% respectively, early maturity of the crop by 7-10 days which allows timely sowing of succeeding crop, reduced methane emission, reduced cost of cultivation by 5000-6000 ha^{-1}. The global warming potential of DSR is 1.9mg ha^{-1}.

Challenges to be addressed in Direct Seeded Rice

- **Poor seedling establishment**

Direct sowing of rice often results in poor seedling emergence. Since traditional direct-seeded rice (DSR) involves sowing seeds on the soil surface, they are highly susceptible to damage by birds and rodents. Additionally, temperature fluctuations and soil erosion caused by rainfall can significantly hinder uniform seedling establishment. However, these challenges can be mitigated by using advanced field preparation methods, such as laser levelling technology.

	
Seedling establishment under Direct Seeded conditions	Puddled transplanted conditions

Weed competition

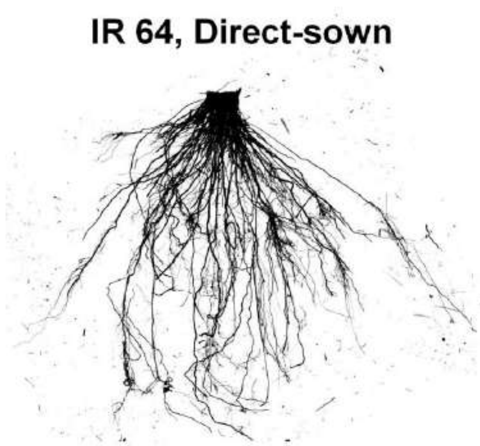
Weeds are the primary biological challenge in direct-seeded rice (DSR), especially in light-textured soils, leading to substantial economic losses. They pose a serious threat to crop growth in DSR, with infestations significantly reducing global rice productivity. Uncontrolled weeds in dry direct-seeded rice (DDSR) can reduce yields by up to 96%, and in wet direct-seeded rice (WDSR), by 61%. Yield losses from weeds in DSR can range from 40% to 100%, and delayed weeding increases weed biomass, negatively impacting crop performance. The weeds that emerge in puddled transplanted conditions are suppressed by the anaerobic conditions created by quick flooding, which does not exist in DSR. Combining manual weeding and herbicides can control the weeds in DSR

Weed infestation in Direct seeded rice

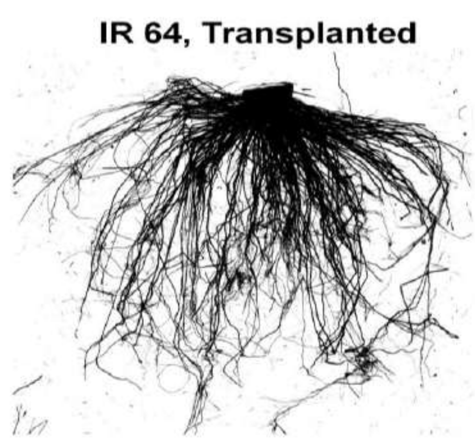
weed free puddled transplanted conditions

Poor root system

In direct-seeded rice (DSR) grown on sandy loam soils, nutrient demand is higher due to increased plant density and greater biomass production during the vegetative phase, compared to puddled transplanted rice (PTR). Lower yields in DSR may also be attributed to reduced nutrient uptake by the roots. Enhancing nutrient absorption under DSR conditions requires an understanding of root structure and distribution. Deeper root growth can boost grain yield and nitrogen use efficiency, while an increase in nodal roots may improve overall nutrient absorption



Root architecture of the variety IR 64 under direct seeded



transplanted conditions

Nematode infestation

The Direct Seeded Rice (DSR) technique has been found to activate certain soil-borne pathogens, including nematodes. Notably, the root-knot nematode, *Meloidogyne graminicola*, is likely to proliferate in the rice root zone, leading to reduced yields. This nematode inflicts significant damage in rainfed lowland, upland, and irrigated rice systems. In India, *M. graminicola* is known to cause rice yield losses ranging from 16% to 32% in upland and rainfed conditions. Under upland cultivation, a grain yield reduction of approximately 2.6% has been observed for every 1000 nematodes per seedling.

Opportunities in Direct Seeded Rice cultivation

Methane Reduction and Environmental Safety:

Direct-seeded rice (DSR) maintains non-puddled soil conditions, enhancing water percolation, soil macro-porosity, and pore continuity, which in turn promotes gas diffusivity and methane (CH_4) oxidation. In contrast, transplanted rice under continuous flooding (TPR-CF) leads to anaerobic, puddled conditions that facilitate CH_4 emissions through anaerobic decomposition. Research from ICAR-NRRI, Cuttack shows that methane emissions are significantly lower in DSR plots managed with wet/dry cycles and zero tillage compared to traditional TPR methods. Furthermore, emissions are minimized in dry-DSR compared to wet and zero tillage DSR approaches. By implementing effective land and water management strategies, such as alternating wetting and drying, DSR can reduce methane emissions by 40-50%. These findings highlight DSR's potential to lower greenhouse gas emissions while supporting sustainable rice production.

Cost Savings and Profitability:

The profitability of DSR varies across regions, with areas having lower labor costs and better access to irrigation showing higher benefit-cost ratios. Recent studies indicate that DSR reduces cultivation costs by 45-48% compared to transplanted rice (TPR), mainly due to efficient crop establishment and water management. This reduction in costs increases profitability by lowering labor, irrigation and tillage expenses. Implementing DSR could result in net savings of INR 9,114 to 10,192 per hectare, potentially generating economic benefits of around INR 10.0 billion if adopted across one million hectares. Additionally, using modern machinery like seed drills can further reduce costs by 25% and decrease seed rates by 50% compared to TPR.

Pros:

- Planting is faster and more straightforward, allowing for timely completion within the designated period.
- The crop matures 7-10 days earlier (115-120 days), facilitating the timely planting of subsequent crops.

- Enhanced water management capabilities and better resilience to water stress.
- Reduced time, energy, and costs associated with cultivation.
- No transplanting-related plant stress.
- Increased profitability, particularly when reliable irrigation is available.
- Improved soil physical conditions.
- Lower methane emissions, with dry direct seeding (DDS) producing less methane than wet direct seeding (WDS) and transplanted rice (PTR).
- Higher overall income due to lower cultivation costs.

Cons:

- High susceptibility to weed infestation, especially with difficult-to-manage weed species.
- Increased reliance on herbicides for weed control.
- Requires farmers to be informed about crop rotation techniques and herbicide resistance management.
- Uneven seedling emergence due to factors like bird predation and temperature fluctuations.
- Higher nutrient demand due to increased plant density and biomass.
- Greater susceptibility to certain pests and diseases, including nematodes.
- Initial investment in DSR-specific machinery and training can be high.
- Requires effective field preparation techniques to improve seedling establishment.
- Potential development of herbicide resistance in weed species due to inappropriate use.

Varieties suitable for direct seeded rice cultivation

CO 53

CO 53 is a rice variety developed from the parentage of PMK (R) 3 and Norungan. It is a short-duration, drought-tolerant variety released by the Department of Rice, Coimbatore, Tamil Nadu. This early-maturing variety reaches maturity in 115–120 days. CO 53 is high-yielding, producing an average grain yield of 3718 kg/ha under dry conditions and 3866 kg/ha under semi-dry conditions. This medium tall variety shows moderate resistance to the White backed Planthopper (WBPH) and multiple diseases, including leaf blast, neck blast, sheath rot, brown spot and Rice Tungro Disease (RTD). The grains are white, short and bold with a high milling percentage of 69.6% and a head rice recovery rate of 59.6%. This variety is particularly suitable for making idlis, a popular South Indian dish. CO 53 is especially suited for cultivation in the drought-prone districts of Tamil Nadu.

TKM 15

TKM 15 was developed from the parentage of TKM (R) 12 and IET 21620 released by rice research station, Tirur. It has a duration of 118 days for direct sowing under dry and semidry conditions, typically sown between September and October. The plant exhibits a semi-dwarf, erect habit with high tillering and non-lodging characteristics. TKM 15 is notable for its impressive grain yield, averaging 3995 kg/ha under dry conditions and 4217 kg/ha under semidry conditions. This variety shows moderate resistance to several diseases, including blast, sheath rot, sheath blight, brown spot and Rice Tungro Disease (RTD). The medium slender grains have a good milling percentage of 68% and a head rice recovery rate of 62.9%. Additionally, under water stress conditions, TKM 15 demonstrates resilience with higher proline content (2.15 mg/g), a Chlorophyll Stability Index of 80.23%, and a total chlorophyll content of 1.51 mg/g.

TKM 13

TKM 13 was developed from the parentage of WGL32100 and Swarna, has a duration of 130 days and is suitable for the Thaladi season. It released by Rice Research Station, Tirur. It boasts an impressive average grain yield of 5938 kg/ha. The grains are medium slender and white, with a 1000 grain weight of 13.5 grams. It also has a high milling yield of 75.5% and head rice yield of 71.7%. This variety shows moderate resistance to several pests and diseases, including leaf folder, stem borer, green leaf hopper, blast, rice tungro disease, brown spot and sheath rot.

Future prospects:

The future prospects for Direct Seeded Rice (DSR) are highly promising due to its numerous advantages and potential to tackle various agricultural challenges. Here are some key points:

- **Sustainability:** DSR is viewed as a sustainable farming practice because of its lower water requirements and reduced methane emissions, making it an environmentally friendly alternative to traditional methods.
- **Water Conservation:** Given the increasing scarcity of water, DSR is a viable solution as it uses significantly less water compared to puddled transplanting, which is crucial for maintaining productivity in water-limited areas.
- **Labor Efficiency:** DSR reduces the need for labor, which is beneficial in regions with labor shortages. The mechanization of sowing and weeding further enhances efficiency.

- **Early Maturity:** Crops mature earlier with DSR, allowing for timely planting of subsequent crops and potentially increasing overall farm productivity.
- **Cost Reduction:** DSR lowers production costs by reducing labor, water, and energy expenses, making it economically attractive for farmers.
- **Climate Resilience:** DSR improves climate resilience by enhancing soil health and reducing greenhouse gas emissions, which is essential for adapting to changing climatic conditions and ensuring food security.
- **Research and Innovation:** Ongoing research and development efforts aim to improve DSR techniques, develop suitable rice varieties, and promote best management practices. Continuous innovation is expected to further enhance DSR adoption.
- **Policy Support:** Government policies and subsidies can encourage farmers to adopt DSR. Support for training, access to machinery, and financial incentives can help overcome initial barriers to adoption.
- DSR has the potential to revolutionize rice farming by offering a more sustainable, efficient, and climate-resilient approach. With continued research, innovation, and policy support, DSR could become a dominant method of rice cultivation in the future.

Volume: 04 Issue No: 12

USES OF AGRICULTURAL PRODUCTS IN AQUACULTURE

Article ID: AG-VO4-I12-106

S. A. Raj Vasanth[1*], J. G. Jerlin Mol[2]

[1]Fisheries College and Research Institute, Thoothukudi-628 008, Tamil Nadu, India

[2]Dr M.G.R. Fisheries College and Research Institute, Ponneri-601 204., Tamil Nadu, India

*Corresponding Author Email ID: raaathiraj@gmail.com

Abstract

Fish farming systems can be improved sustainably by incorporating agricultural products into aquaculture. By using agricultural by-products such fruit peels, oilseed meals, and crop residues as nutrient-dense and reasonably priced feed ingredients, reliance on pricey commercial feeds is lessened. By reducing agricultural waste, these materials also help environmental sustainability by aiding in waste valorisation. Photobiotic and essential oils are examples of plant-based products that boost immunity and support gut health, which benefits fish health and growth. Moreover, the application of agricultural goods to pond fertilization increases primary productivity, guaranteeing aquatic organisms' natural access to food. Aquaculture systems' sustainability is improved, production costs are decreased, and resource efficiency is encouraged by this collaboration between agriculture and aquaculture.

Keywords: Oilseed Meals, Fruit Peels, Aquaculture, Agricultural.

Introduction

Aquaculture, which involves raising aquatic organisms like fish, crabs, mollusks, and aquatic plants, has expanded dramatically in recent years in response to the growing demand for seafood around the world. A key innovation in this industry's ongoing growth is the incorporation of agricultural goods into aquaculture systems. These products, ranging from plant-based feed ingredients to agricultural by-products, provide a range of benefits that enhance sustainability, productivity, and economic viability in aquaculture.

Enhancing Sustainable Feed Production:

One of the most significant contributions of agricultural products to aquaculture is in the formulation of sustainable and cost-effective feeds. Traditional aquaculture feeds rely heavily on fishmeal and fish oil, derived from wild-caught fish, which are both costly and environmentally unsustainable. The substitution of these ingredients with plant-based alternatives, such as soybean meal, corn gluten, wheat, and rice bran, has revolutionized feed production. Soybean meal, for instance, is rich in protein and serves as an excellent substitute for fishmeal. Its widespread availability and lower cost make it a practical choice for aquafeed manufacturers. Similarly, agricultural by-products like rice bran and wheat middlings, which are often discarded as waste in traditional farming systems, can be repurposed as nutrient-rich feed components. These plant-based ingredients not only reduce the reliance on marine resources but also decrease feed costs, making aquaculture more accessible to small-scale farmers. Additionally, incorporating agricultural products into feed improves the nutritional profile of aquafeeds. Advanced processing techniques, such as extrusion and fermentation, enhance the digestibility and bioavailability of nutrients in plant-based ingredients. For example, fermented soybean meal is less likely to cause digestive issues in fish and has been shown to improve growth rates in species such as tilapia and salmon.

Effective Waste Management:

The integration of agricultural by-products into aquaculture systems also contributes to efficient waste management. Many agricultural residues, such as fruit peels, vegetable scraps, and crop stalks, can be processed and used as feed or as components in biofilters. These practices not only reduce agricultural waste but also help in recycling nutrients within the ecosystem. Aquaponics, a system that combines aquaculture with hydroponic agriculture, exemplifies this synergy. In aquaponics, fish waste serves as a nutrient source for growing plants, while the plants, in turn, purify the water for the fish. Agricultural products, such as compost or organic fertilizers derived from farm waste, can further enhance plant growth in these systems. This closed-loop approach minimizes waste output and creates a sustainable cycle of resource utilization.

Environmental Conservation:

Agricultural products play a crucial role in mitigating the environmental impact of aquaculture. The overuse of fishmeal and fish oil not only depletes wild fish stocks but also contributes to environmental degradation through excessive nutrient loading in aquatic ecosystems. By replacing these traditional feed ingredients with plant-based alternatives, aquaculture operations can significantly reduce their ecological footprint. Moreover, agricultural products such as biochar, a carbon-rich material derived from crop residues, are being increasingly used in aquaculture ponds to improve water quality. Biochar adsorbs harmful substances like ammonia and nitrates, maintaining a healthier environment for aquatic organisms. This practice reduces the need for chemical treatments and enhances the overall sustainability of aquaculture systems. The use of agricultural products also promotes the cultivation of integrated multi-trophic aquaculture (IMTA) systems. In IMTA, different species are farmed together in a way that mimics natural ecosystems, where waste from one species becomes a resource for another. For example, seaweeds and shellfish can utilize nutrients from fish waste, while agricultural inputs like plant-based feed or organic fertilizers support the entire system's productivity.

Economic Benefits:

The economic advantages of using agricultural products in aquaculture are manifold. For farmers, the availability of affordable and locally sourced feed ingredients reduces operational costs and increases profit margins. This is particularly beneficial for small-scale aquaculture enterprises in developing countries, where access to expensive imported feed is often limited. Furthermore, the use of agricultural by-products creates additional revenue streams for the agricultural sector. Farmers can sell crop residues and by-products, which would otherwise go to waste, to aquafeed manufacturers or aquaponic systems. This interdependence strengthens rural economies and fosters collaboration between agriculture and aquaculture industries. The development and commercialization of agricultural products for aquaculture also drive innovation and job creation. Research into novel feed ingredients, such as algae, insect-based proteins, and plant extracts, is expanding rapidly. These advancements not only benefit aquaculture but also open up new markets and opportunities for agricultural stakeholders.

Promoting Food Security:

The integration of agricultural products into aquaculture contributes significantly to global food security. By reducing the dependency on wild-caught fish for feed and production, aquaculture can grow sustainably to meet the dietary needs of a growing population. Plant-based feeds and agricultural by-products enable the production of high-quality, affordable seafood, which is a crucial source of protein and essential nutrients for millions of people worldwide. Additionally, aquaponics systems, supported by agricultural products, provide a sustainable means of producing both fish and vegetables in a single system. These systems are particularly valuable in urban and peri-urban areas, where land and water resources are limited. By producing food locally, aquaponics reduces transportation costs and carbon emissions, further enhancing food security.

Challenges and Future Directions:

Despite the numerous benefits, the use of agricultural products in aquaculture is not without challenges. One major concern is the anti-nutritional factors (ANFs) present in some plant-based feed ingredients, such as phytic acid and tannins, which can impair digestion and nutrient absorption in fish. However, advancements in feed processing technologies, such as enzymatic treatment and fermentation, are addressing these issues effectively. Another challenge is the competition between human food and animal feed for agricultural resources. Ensuring that the use of crops in aquaculture does not compromise food availability for humans is critical. Promoting the use of non-edible agricultural by-products and exploring alternative ingredients, such as algae and insect proteins, can help mitigate this concern. Looking ahead, interdisciplinary research and collaboration between agriculture and aquaculture sectors will be essential to unlock the full potential of agricultural products. Policies that support sustainable practices and incentivize the use of agricultural by-products can further drive innovation and adoption in the industry.

Conclusion

The integration of agricultural products into aquaculture offers a sustainable and economically viable pathway to meet the growing global demand for seafood. By replacing traditional feed ingredients with plant-based alternatives, repurposing agricultural waste, and enhancing resource efficiency, these products contribute to the environmental, economic, and social sustainability of aquaculture. As the sector continues to evolve, the synergy between agriculture and aquaculture will play a pivotal role in promoting food security and fostering a more sustainable future. With ongoing advancements and collaborative efforts, the use of agricultural products in aquaculture has the potential to revolutionize the way we produce food, ensuring a balance between economic growth and environmental stewardship

References

Alleway, H. K., Gillies, C. L., Bishop, M. J., Gentry, R. R., Theuerkauf, S. J., & Jones, R. (2019). The ecosystem services of marine aquaculture: valuing benefits to people and nature. BioScience, 69(1), 59-68.

Arshad, N., Samat, N., & Lee, L. K. (2022). Insight into the relation between nutritional benefits of aquaculture products and its consumption hazards: A global viewpoint. Frontiers in Marine Science, 9, 925463.

Howgate, P. (1998). Review of the public heath safety of products from aquaculture. International journal of food science & technology, 33(2), 99-125.

Humphries, F., Benzie, J. A., Lawson, C., & Morrison, C. (2021). A review of access and benefit-sharing measures and literature in key aquaculture-producing countries. Reviews in Aquaculture, 13(3), 1531-1548.

Kinnucan, H. W., Nguyen, L., & Das, A. (2021). Benefits of agricultural R&D international spillovers: the case of aquaculture. Aquaculture, 535, 736308.

Mantovani, A., Ferrari, D., & Frazzoli, C. (2015). Sustainability, security and safety in the feed-to-fish chain: focus on toxic contamination. Int J Nutr Food Sci, 4(2-2), 6-24.

Napier, J. A., Haslam, R. P., Olsen, R. E., Tocher, D. R., & Betancor, M. B. (2020). Agriculture can help aquaculture become greener. Nature Food, 1(11), 680-683.

Stevens, J. R., Newton, R. W., Tlusty, M., & Little, D. C. (2018). The rise of aquaculture by-products: Increasing food production, value, and sustainability through strategic utilisation. Marine Policy, 90, 115-124.

Xu, Q., Dai, L., Gao, P., & Dou, Z. (2022). The environmental, nutritional, and economic benefits of rice-aquaculture animal coculture in China. Energy, 249, 123723.

Volume: 04 Issue No: 12

GROWING OF QUALITY PLANTING MATERIAL OF VEGETABLE CROPS-A SUCCESS STORY

Article ID: AG-VO4-I12-107

***Raj Kumar[1], K. K. Pande[2], N.K. Singh[2] and H.C. Joshi[2]**

[1]Senor Scientist and Head, [2]SMSs, KVK (ICAR-VPKAS), Bageshwar Uttarakhand, 263628, India

*Corresponding Author Email ID: rajhortches@gmail.com

Introduction

Sh. **Parmar Rajesh Kumar R. is** a resident of village - Mokal, Taluka - Kalol, Dist.-Panchmahal, Gujarat 389 320. He is having 3.5 acre irrigated land. He grows maize, pigeon pea, cucurbitaceous vegetables, etc, etc with traditional system. He was not satisfied with the income earned from agriculture. He wanted to get more income through vegetable nursery. He came regularly in various programs conducted by KVK-Panchmahal (ICAR-CIAH). The climatic conditions of the area are characterized as hot semi arid. The annual rainfall is mainly confined during the monsoon period (July- September) and actual mean precipitation is about 650-820 mm and average number of rainy days is 32.55-36.22. The mean annual maximum and minimum temperatures vary from 42-47°C (May) and 6-9° C (January), respectively. The soil of area is reddish loamy sand with available N (145.70-147.60 kg/ha), P (6.40-8.60 kg/ha) and K (144.40-147.20kg/ha) and organic carbon (0.31%), while EC (0.13-0.16 dSm^{-1}) and *pH* (8.00). The soil depth ranged from 0.93 to 1.35m derived from mixed alluvial basalt, quartzite, granite and layers of limestone. The availability of ground water is low and salty. The area, production and productivity of venerable crops in the district are given in table-1.

The productivity of vegetable crops of the district is low as compression to State and National level. The major factors responsible are small land holding, non availability of quality planting material, poor awareness about advance production technologies, poor irrigation facility, etc. Among them availability of quality planting material of vegetable crops are the major problem in its cultivation. The demand of quality planting material of vegetable crops is increase day by day.

Table-1 Area, production and productivity of vegetable crops in Panchmahal Gujarat 2020-21

S. No.	Crop	Area (ha)	Production (MT)	Productivity (MT)
1.	Brinjal	2544	48845	19.20
2.	Tomato	1050	22575	21.50
3.	Cauliflower	1130	19549	17.30
4.	Cabbage	1105	18619	16.85
5.	Cluster beam	1615	16473	10.20
6.	Okra	2798	27700	9.90
7.	Onion	107	2386	22.30
8.	Cowpea	1035	10454	10.10
9.	Cucurbits	3440	46366	13.48
10.	Others	3506	67248	19.18
Total Panchmahal		**18330**	**280215**	**16.01**

Plan implement and support: He came in contact with KVK to get more income from agriculture especially from vegetable nursery. KVK Panchmahal advised him for production of quality planting material of vegetable crops and participates in training program. He came in various programs like as training, meeting, campaigns organized by KVK time to time.

Field visit and layout for nursery

Raising of nursery in pro-tray

Nursery in polytunnel Healthy

Brinjal nursery on raised bed

KVK experts helped him in preparation of beds, selection of crop, varieties, period of nursery raising, preparation of beds, seed treatment, sowing of seed, irrigation, hardening of seedlings, pest and disease management. The various extension activities were carried out by KVK for at horizontal dissemination of the technology.

Output and outcome: He produced total 436000 healthy plants of various vegetable crops (brinjal, tomato, chilli and cauliflower) during 2023-24. These plants were sold to the various farmers. He is adopting all techniques and suggestion as provided by the KVK experts time to time. He got very good income by adopting these simple technologies. The number of plants, cost of production, gross return, net return and cost benefit ratio of various crops are given in table -2. The total cost of production (₹1, 85,000), gross return (₹ 6, 58,250) and net return (₹ 4, 73,250) and average cost benefit ratio (3.56) were recorded. The economics of raising of vegetable nursery are given in table -2.

Table -2 Economics of vegetable nursery 2023-24

Crop	Plant produced (Nos)	Rate /plant (₹)	Cost of production (₹)	Gross income (₹)	Net income (₹)	B:C ratio
Brinjal	113000	1.25	45,000	1,41,250	96,250	3.14
Tomato	125000	1.50	55,000	1,87,500	1,37,500	3.75
Chilli	133000	1.50	55,000	1,99,500	1,44,500	3.63
Cauliflower	65000	2.0	35,000	1,30,000	95,000	3.71
Total	**436000**	**-**	**1,85,000**	**6,58,250**	**4,73,250**	**3.56**

Impact: Now he is a key person in production of quality planting material of vegetable crops. He is very happy and earned very smart income from nursery business. He provided the employment to 5-7 rural youths. The other innovative framers were inspired and adopt nursery business. Now he is increase the area and number of crops like as onion, cabbage, fennel, etc. Recently in the district more than 15 vegetable nurseries are established and produced quality planting materials and provided to the farmers.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

NATIONAL CERTIFICATION AND QUALITY MANAGEMENT OF TISSUE CULTURE PLANT

Article ID: AG-VO4-I12-108

[1]Adavi Lakshmi Nikhil., [2*]V. Krishnan., [1]V. B. Divyadarshini, [1]P. Sowmiya, [1]C. S. Subash Chandra Bose and [1]A. Shivada

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

As the demand for agriculture, forestry, plantation and horticulture crops increasing with the increase in population, the demand for high quality, high yielding, disease free, planting material has been increasing over two decades. It is difficult to meet this increasing demand through conventional propagation methods which includes seed propagation, vegetative propagation like cuttings, layering etc. Their limitations like number of plants produced, non-uniformity of quality, disease spreading etc. In this scenario Plant Tissue Culture an important biotechnological tool has emerged which is able to commercially multiply high quality, disease free and high yielding varieties of plants in laboratory conditions irrespective of the season. In India the growth rate tissue culture industry is 15% per annum.

Introduction of Plant tissue culture technology has become important for the commercialization of vegetative propagated crops where seed propagation is not possible like banana etc. But the certification of this tissue culture plants is important to ensure the production of disease-free plants, so as to prevent the spread of the diseases and also to standardize protocols to prevent variations in plants produced. This requirement has led to the development of the well organized and structured system to provide assistance to plant tissue culture technology for commercialization of tested virus, disease free and high-quality planting material

National Certification System for Tissue Culture Plants (NCS-TCP) is the unique quality management system established by Department of Biotechnology (DBT), Ministry of science and technology, Government of India that are authorized as certification agency via the Gazette notification dated 10th March 2006 under the section 8 of the Seeds Act,1966 which notified that "In exercise of the powers conferred under section 8 of the seeds Act, 1966 (54 of 1966), the Central Government hereby authorizes Department of Biotechnology, Ministry of Science and Technology, Government of India to act as Certification Agency for the purpose for certification of the tissue culture-raised propagules up to laboratory level and to regulate its genetic fidelity as prescribed by them."

FUNCTIONS OF NCS-TCP:

- ✓ **Certifying tissue cultured plants:**

  NCS-TCP is associated with the certification of the tissue cultured plants that are of high quality and disease free.

- ✓ **Recognizing tissue culture production facilities:**

  NCS-TC recognizes the facilities that produce tissue culture plants and accredited them.

- ✓ **Accrediting test laboratories:**

  It accredits the laboratories that test for viruses and genetic uniformity.

- ✓ **Developing standard protocols:**

  It also develops standard protocols for tissue culture to prevent disease spreading and maintain genetic uniformity.

- ✓ **Training and capacity building:**

  It provides training and helps in capacity building of the tissue culture production facilities in production of quality planting material.

- ✓ **Monitoring of the labs and production facilities:**

  It monitors the implementation of program and following of the standard protocol.

- ✓ **Creating awareness:**

  It also creates awareness among people by conducting awareness programmes.

- ✓ **Providing information:**

  Provides information about the program and manages information related to it.

- ✓ **Providing labels**:

  Provides certification labels for tissue cultured plants which includes the information about the plant, production facility and the contact person.

ORGANIZATIONAL STRUCTURE:

A well organized and defined structure has been developed by the DBT which includes the following components (Figure 1.).

- ✓ Tissue Culture Certification Agency (TCCA)
- ✓ NCS-TCP Management cell (NMC)
- ✓ Referral centre's
- ✓ Accredited Test Laboratories
- ✓ Recognized Tissue Culture Production Facilities.

COMPONENTS OF NCS-TCP:

1.Tissue Culture Certification Agency:

Department of Biotechnology is responsible for implementing the National certification system for tissue culture plants (NCS-TCP) in the country. NCS-TCP Management cell (NMC) has been formed for managing the NCS-TCP and helps DBT in its implementation in the country. Referral laboratories have been developed for carrying out confirmatory tests when required and also for developing standard protocols, validating protocol and diagnostic reagents, maintaining of referral material, providing training for the persons working at accredited test laboratories (ATLs), providing the required diagnostic reagents to ATLs etc. The certification Agency is overall responsible for developing standard tests, production protocols / guidelines and manuals.

2.NCS-TCP Management cell (NMC):

NMC has been established at biotech consortium India Limited (BCIL),5th floor, Anuvrat Bhawan,210 Deendayal Upadhyaya Marg, New Delhi -110002 for helping DBT in implementation of NCS -TCP in country. It is responsible for the Accreditation of Test Laboratories for virus diagnosis and genetic fidelity/ uniformity testing of tissue culture plants and Recognition of Tissue culture raised facilities and its renewal. NMC is also responsible for advisory services to DBT for new initiatives, updating of SOP's, guidelines and management of information.

Fig. 1 NCS-TCP

3.Referral Centres:

The DBT has designated Referral Centre's for virus diagnosis and genetic fidelity tissue cultures plants.

- ✓ Referral Centre for virus Diagnosis -Indian Agriculture Research Institute (IARI), New Delhi

- ✓ Referral Centre's for Genetic fidelity/Uniformity – National Research Centre on Plant Biotechnology (NRCPB), New Delhi.

The functions of Referral Centre's include carrying out conformation test in case of nonuniformities / disputes, developing standard protocols, validating protocol and diagnostic reagents, maintenance of referral materials, providing training for persons working in ATLs, providing the required diagnostic reagents to ATLs. The referral centres are not involved in the regular viral diagnosis/genetic fidelity/ uniformity testing of tissue cultured plants instead they are responsible for undertaking random sample tests at different test laboratories as per decision of DBT.

4.Accredited Test Laboratories:

Test laboratories are accredited under NCS-TCP for testing the Tissue culture material for virus diagnosis and genetic fidelity / uniformity, to certify them. The test reports are prepared based on the tests conducted to check the conformity with the standards / protocol / guidelines which helps to authorize the ATLs to issue the Certificate of Quality for the Tissue Cultured Plants (CQ-TCP) along with certification label on behalf of the Tissue Culture Certifying Agency only after they are tested for both genetic uniformity and true to type. Each ATL would perform test for both viral diagnosis and true to type and also responsible for maintaining / procuring all diagnostic kits, probes etc. 5 ATLs are under NCS-TCP to perform test and certify tissue cultured plants from Recognized TCPFs

- ✓ National Research Center for Banana (NRCB), Trichy
- ✓ University of Agricultural Science (UAS), Bengaluru
- ✓ Vasantdada Sugar Institute (VAS), Pune
- ✓ Indian Institute of Sugarcane Research (IISR) Lucknow
- ✓ Central Potato Research Institute (CPRI), Shimla

5.Recognized Tissue Culture Production Facility:

Commercial Tissue Culture Production Facility with a minimum production capacity of 0.5million plants/annum are assessed by the Accreditation panel (AP) for their compliance with NCS-TCP guidelines to get Recognised. The comprehensive assessment report by AP includes observation on infrastructure, technical/scientific expertise and package of practices. These production facilities are eligible to get their plantlets certified by the accredited test laboratories. These facilities are responsible for adopting Standard Operating Procedure (SOP) and maintain all relevant records. This recognition of the tissue culture production facilities is only for a period of 2 years which would be re-assessed for ''Renewal of Recognition".

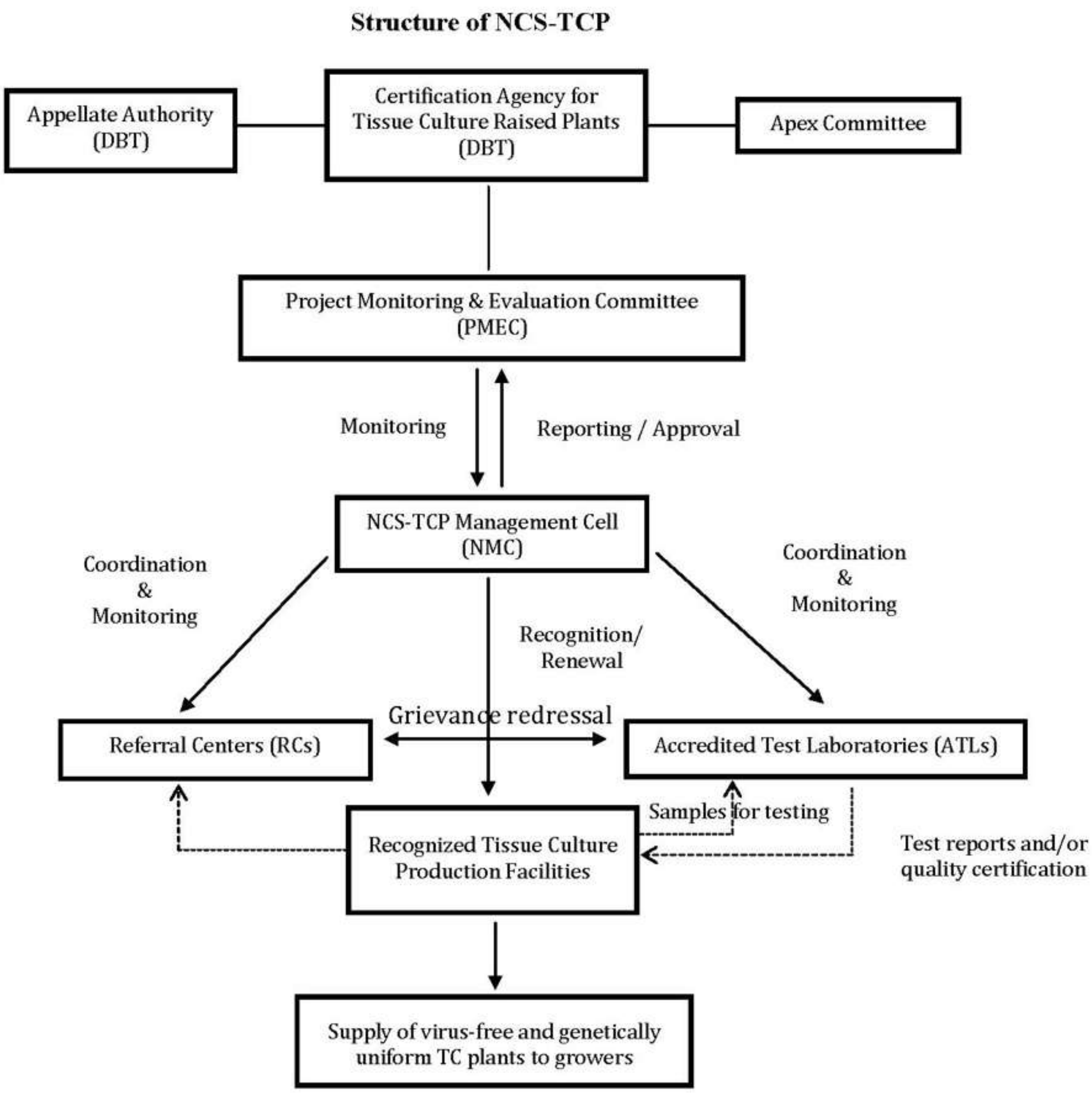


Fig. 2. Structure of NCS-TCP

CERTIFICATION OF TISSUE CULTURE RAISED PLANTS

Prior to the certification of tissue culture raised plant "Mother Plant Tissue/Stock Culture(s)" need to be indexed for all known virus listed under NCS-TCP.

1. All mother plants/stock cultures must be indexed for all the viruses affecting the plant species listed in NCS-TCP website.

(a). testing should ideally be done on individual mother plants/stock cultures should be tested.

(b). If the number of mother plants/stock culture are more, then samples from batches consisting of no more than 10 mother plants/stock cultures may be pooled for testing.

In such cases –

(i) The tissue culture unit must maintain a proper record of individual mother plants/stock cultures of each batch, so that individual mother plants/stock cultures or smaller batches could be tested, in cases where the pooled samples are found positive for infection, and also only the cultures from infected mother plant/stock culture are discarded.

(ii) If testing is not done as said in 1(b) (i), all the cultures generated from the infected mother plants/stock cultures will have to be discarded.

2. Virus testing can be done ATLS or any Govt. Institute or University having facilities and expertise for virus testing.

Only Recognized Tissue Culture Production Facilities will be eligible to register for certification of plant tissue culture raised material. ATL would not accept the sample of tissue culture raised plants for certification if the mother plant/stock culture has not been indexed for respective batch of TC plants.

The Tissue Culture Production Facility will register its application for Certification of Tissue Culture material with the nearest ATL through filling “Intimation form for (Virus/ genetic fidelity) Testing for Batch Certification of Tissue Culture Raised Plants” using online web portal. The above request should reach the ATL ,2 weeks before the sample is being sent. The ATL will examine the application and intimate the applicant (in two working days), regarding requirements requisite fee for the testing if it is accepted.

The fees for batch certification of tissue culture raised plant should be paid online and the sample would be dispatched. Print of Application form will be delivered at the ATL with the samples. Application form can be downloaded from NCS-TCP web site.

The ATLs, will arrange for site inspection, receipt of samples, testing etc as per prescribed format. On receipt of requisite fee ATL personal should visit the hardening facilities of recognized tissue culture production facilities for collecting samples for batch certification. The cost of the visit might be borne by the ATL under travel head.

Certificate of Quality and Certification label

The ATL will generate the Test Report within the prescribed time and based on the test report the Certificate of quality will be issued as per prescribed norms. On preparation of Certificate of Quality, NMC would issue 10 number of certification labels that are correctly signed and stamped for pasting on the packages of delivery of tissue culture plants as prescribed under certification standards established by the Department of Biotechnology in accordance with provisions of Seeds Act, 1966. Additional label will be provided by NMC to TCPFs only on written request from company without any charges.

Correctly signed/stamped certification labels will be dispatched by NMC to the Tissue Culture Production Facility after issuance of certificate of quality of tissue culture raised plants for pasting on the packages/accompanying with dispatched planting material.

Process Flow and Relevant Formats for Testing and Certification of Tissue Culture Raised Plants

Intimation form will be received from TC companies for testing and certification of TissueCulture raised plants preferably at least two weeks before the samples received. ATL will acknowledge the intimation and inform the company regarding fee to be submitted for

Samples will be received along with application covering detailed such as batch number/size and requisite fee. Each batch will be assigned unique 42 digits batch registration number by ATLs

The samples would be forwarded by in- charge,Division of ATLs torespective lab technical/research assistent person with a job card

The laboratory technician (Virology/Molecular Biology) after testing will prepare a test report and submit to concerned scientist to verify and sign the test report

Director/HoD of ATL will issue a "Certificate of Quality" based on test report to the concerned TCPF

NMC will issue required number of certification labels to the company only if thhe samples are free from known viruses and/or true to type along with" certificate of Quality" issue by ATL.

If the test report is positive for virus or not found to be true to type,the Director/HoD of ATL will issue a certificate disapproval to the concerned TCPF

In case of dispute,the concerned ATL will forward the sub sample to referral laboratory

The ATL will maintain the whole record in master register for testing and certification of Tissue culture raised plants

References

Seeds Act, 1966, Seeds Rule, 1968and Gazette Notification issued by the S.O. No. 306(E) dated 10th March, 2006 under Section-8 of the Seeds Act, 1966.

Guidelines for Accreditation of Test laboratory for virus diagnosis and Genetic fidelity testing of tissue culture raised plants and Certification of Tissue Culture Production Facility, 2006, Department of Biotechnology, Ministry of Science & Technology, Govt., of India, New Delhi

Standard Operating Procedures for Accredited Test Laboratory, 2008, Department of Biotechnology, Ministry of Science & Technology, Govt., of India, New Delhi.

Standard Operating Procedures for Tissue Culture Production Facility, 2008, Department of Biotechnology, Ministry of Science & Technology Govt., of India, New Delhi.

Crop Specific Tissue Culture Standards developed by the Department of Biotechnology, Ministry of Science & Technology, New Delhi.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

MULTI-FACETED USES OF CASTOR- BASED PRODUCTS

Article ID: AG-VO4-I12-109

Gowsalya. R[1], Natarajan.S.K[2]*, Rithiga. R[3], Elankavi. S[4], Jaya Prabhavathi .S[5]

[1]PG Scholar , Department of Agronomy, Agricultural College and Research Institute, Madurai, Tamil Nadu, India- 625 104.

[2*]Associate Professor, Department of Agronomy, Tapioca and Castor Research Station, Yethapur, Tamil Nadu, India- 636 119.

[3]PG Scholar, Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirapalli, Tamil Nadu, India- 620 027.

[4]Associate Professor, Department of Agronomy, Tapioca and Castor Research Station, Yethapur, Tamil Nadu, India- 636 119.

[5]Associate Professor, Department of Agricultural Entomology, Tapioca and Castor Research Station, Yethapur, Tamil Nadu, India- 636 119.

*Corresponding Author Email ID: natarajan.s.k@tnau.ac.in

Abstract

The castor plant (*Ricinus communis*) is increasingly recognized for its wide range of sustainable applications beyond its primary use in oil production. Known for its unique fatty acid profile, castor oil is integral to industries such as biofuels, bioplastics, pharmaceuticals, and specialty chemicals. Castor by-products, including castor meal, husks, and shells, serve valuable roles in agriculture as nutrient-rich organic fertilizers and biofuels. These by-products enhance soil fertility, support crop yield, and provide a renewable energy source, contributing to eco-friendly practices. The medicinal applications of castor oil are extensive, with proven uses in laxatives, skin care, anti-dandruff treatments, and pharmaceutical coatings. Industrially, castor oil derivatives play key roles in lubricants, biodegradable polymers, paints, and adhesives due to their stability, viscosity, and water resistance. As demand for renewable and sustainable materials rises, castor oil and its by-products represent a promising resource for a circular

economy. This review highlights castor plant products' vast potential to support sustainable practices and reduce reliance on synthetic materials, meeting the needs of a resource-conscious global economy.

Key words: Castor; products; lubricants; industrial; medicinal; bio-diesel

Introduction:

Castor plant (*Ricinus communis*) is from the family Euphorbiaceae and grows wild in varied climatic conditions. Owing to its rich properties and variety of end-uses, together with increased interests in biopolymer and biofuels industries, the potential for castor oil to play a much larger role in the world economy has increased dramatically in recent years. The oil produced from this crop is considered to be of importance to the global specialty chemical industry because it is the only commercial source of a hydroxylated fatty acid (Severino et al., 2012). Castor by-products hold significant potential for sustainable and innovative applications beyond the primary extraction of castor oil. After oil extraction, the remaining castor meal is highly valued in agriculture as an organic fertilizer and soil amendment. Rich in nitrogen, phosphorous, and other nutrients, it aids in soil conditioning and boosts crop yield while being environmentally friendly.

Figure 1: Castor- based products

Although castor meal contains ricin, a toxic protein, it can be detoxified for use in animal feed, offering a sustainable protein source in livestock nutrition. In addition to agricultural applications, castor husks and shells, which are often discarded, are gaining attention as biomass fuel. Due to their high calorific value, these husks can be converted into biofuels, briquettes, or even biogas, offering a renewable energy source that helps reduce dependency on fossil fuels. Furthermore, castor plant residues are increasingly utilized in producing biodegradable polymers and bioplastics, which serve as sustainable alternatives in packaging and manufacturing. These by-products not only promote waste minimization and renewable energy generation but also contribute to circular economy practices. As industries look for eco-friendly resources, castor by-products stand out as versatile materials with applications that extend into pharmaceuticals, animal feed, cosmetics, and more

Castor by-products Utilization:

Castor meal as Organic fertilizer:

Castor meal, a by-product obtained after extracting oil from castor seeds, is an excellent organic fertilizer widely used in sustainable agriculture. Known for its rich nutrient profile, it contains high levels of nitrogen, phosphorous, potassium and organic matter, which are essential for plant growth and soil health (Tab. 1). Castor meal is especially valued by organic farmers, as it improves soil fertility without the harmful chemicals present in synthetic fertilizers, enhancing both soil structure and nutrient content

Table 1: Chemical composition of castor meal and castor husks

Nutrient	Castor Meal (g kg^{-1})	Castor husk (g kg^{-1})
Nitrogen	75.4	18.6
Phosphorus	31.1	2.6
Potassium	6.6	45
Calcium	7.5	6.7
Magnesium	5.1	3.8

(Lima et al., 2011)

Medicinal uses:

Castor oil and other components of the castor plant have been utilized in traditional and modern medicine due to their therapeutic properties. Known primarily for its powerful anti-inflammatory, laxative, and antimicrobial effects, castor oil is applied in various treatments.

1. **Laxative:** Castor oil is a well-known stimulant laxative, commonly used to relieve constipation. The oil contains ricinoleic acid, which stimulates intestinal muscles, promoting bowel movements. However, it should be used in moderation as excessive intake can cause cramping and dehydration.

2. **Detoxification:** In traditional medicine, castor oil is sometimes used in detox regimens to cleanse the digestive tract, though modern use of this approach should be done under medical supervision.
3. **Moisturizer and Healer**: Castor oil is an effective emollient and is widely used to treat dry skin conditions, such as eczema and psoriasis. It hydrates the skin deeply and helps restore its natural barrier, making it smoother and more resilient.
4. **Acne Treatment**: A light application on acne-prone skin can help control breakouts and inflammation.
5. **Pharmaceutical Coatings**: Hydrogenated castor oil, often called castor wax, is used as a coating in pharmaceutical tablets and capsules. It helps control the release of active ingredients and improves the shelf life of products by creating a protective barrier against moisture.
6. **Ointment Base**: Castor wax is also used as a thickening agent in creams and ointments, providing a smooth texture and allowing for even application on the skin.
7. **Emulsified Castor Oil for Cleansing**: Emulsified forms of castor oil are used in various cleansing products, especially in oil-based facial cleansers. Due to its solubility and ability to dissolve impurities, it is effective for removing dirt, makeup, and excess oils without drying the skin.
8. **Anti-Dandruff and Scalp Health Solutions**: Emulsions of castor oil are often found in scalp treatments targeting dandruff. They help reduce flakiness, moisturize the scalp, and inhibit the growth of dandruff-causing microbes.

Industrial uses of Castor:

The castor plant, especially its oil, plays a significant role in various industrial applications due to its unique chemical composition, particularly the presence of ricinoleic acid. Castor oil's high viscosity, stability, and solubility make it valuable in producing lubricants, cosmetics, plastics, and other specialized materials. Here are some major industrial uses of castor and its derivatives:

1. Lubricants and Greases

- **High-Performance Lubricants**: Castor oil is highly viscous and retains its lubricating properties at both high and low temperatures, making it ideal for high-performance lubricants in engines, aviation, and machinery. Its natural properties allow for smoother operation, reduced wear, and better performance in extreme conditions.

- **Biodegradable Lubricants**: Due to its renewability and biodegradability, castor oil is increasingly used in eco-friendly lubricants for industrial machinery, hydraulic fluids, and other applications where synthetic oils may be less sustainable.

2. Polymers and Bioplastics

- **Nylon Production**: Castor oil is used as a raw material in producing nylon 11 and nylon 6,10, which are types of biobased polymers (Singh et al., 2023). These materials are used in high-performance applications such as automotive components, electrical appliances, and sports equipment.
- **Biodegradable Plastics**: Castor oil-based bioplastics are a sustainable alternative to conventional plastics, offering the advantage of biodegradability. These plastics are used in packaging, agricultural films, and consumer products, reducing plastic pollution.

3. Paints, Coatings, and Sealants

- **Paint and Varnish Ingredients**: Castor oil is used as a drying oil in paints, varnishes, and enamels, offering durability, flexibility, and a glossy finish. It helps paints dry faster and adhere well to surfaces.
- **Waterproof Coatings**: Due to its water-resistant properties, castor oil derivatives are used in waterproof coatings for textiles, roofs, and outdoor surfaces, improving longevity and reducing maintenance.
- **Sealants and Adhesives**: Castor oil is used as a base in the production of adhesives and sealants, providing high adherence and flexibility. These products are used in construction, automotive, and furniture manufacturing.

4. Cosmetics and Personal Care Products

- **Soaps and Detergents**: Castor oil's ability to produce a stable, creamy lather makes it a popular ingredient in natural soaps, shaving creams, and detergents. It is known for its gentle, moisturizing effect, making it suitable for sensitive skin.
- **Hair and Skin Products**: Due to its emollient properties, castor oil is widely used in hair conditioners, moisturizers, and creams to improve hydration, shine, and smoothness. It’s a common ingredient in lip balms, mascaras, and other personal care items due to its safe and effective moisturizing capabilities.

5. Chemical Intermediates

- **Surfactants**: Castor oil is used in the production of surfactants and emulsifiers, which are essential in producing detergents, shampoos, and household cleaning agents (Xu et al., 2023). These surfactants help disperse oils and lift dirt from surfaces, improving cleaning efficiency.
- **Dehydrated Castor Oil (DCO)**: DCO is used as a starting material for various industrial chemicals. It is a major component in producing synthetic resins and plasticizers, which are used in products ranging from electronics to paints and coatings.

6. Biofuels

- **Biodiesel Production**: Castor oil is used in the production of biodiesel, an alternative to conventional diesel fuel. Castor oil biodiesel has a high cetane number (a measure of combustion quality), making it efficient and reducing emissions. As a renewable resource, it contributes to sustainable energy solutions.
- **Aviation Biofuel**: Castor oil-based biofuel is increasingly considered for aviation due to its high energy density and stability. It is being tested as a component in jet fuel to reduce carbon emissions and fossil fuel dependency in the aviation industry.

7. Pharmaceutical and Medical Applications

- **Pharmaceutical Excipients**: Castor oil derivatives, such as hydrogenated castor oil, are used as excipients in pharmaceutical tablets and capsules to control drug release and improve stability.
- **Medical Polymers**: Castor oil-based polymers are used in manufacturing medical devices, implants, and wound dressings due to their biocompatibility and degradability.

8. Textiles and Leather

- **Softening and Waterproofing Agents**: In the textile and leather industries, castor oil is used as a softening agent and to add water-resistant properties. It improves texture and flexibility, helping fabrics retain their quality and appearance.
- **Printing Inks**: Castor oil is an ingredient in some printing inks due to its ability to provide a smooth, stable application. It is commonly used in inks for textiles and certain packaging materials.

Conclusion

The castor plant, particularly its oil and by-products, showcases impressive versatility and potential across various sectors. From agriculture and medicine to industrial applications and renewable energy, castor products contribute significantly to sustainable and innovative practices. Castor meal is a valuable organic fertilizer that promotes soil health, while castor husks and shells offer renewable energy alternatives. In medicine, castor oil's therapeutic properties support a range of treatments, and in industrial manufacturing, its unique chemical composition enhances the production of high-performance lubricants, biodegradable plastics, and more. As global industries increasingly prioritize eco-friendly and renewable resources, castor by-products represent a valuable, sustainable choice with extensive applications that support a circular economy. The future of castor looks promising, offering solutions that meet the demands of a resource-conscious world.

References

Lima, R. L., Severino, L. S., Sampaio, L. R., Sofiatti, V., Gomes, J. A., & Beltrão, N. E. (2011). Blends of castor meal and castor husks for optimized use as organic fertilizer. *Industrial crops and products*, *33*(2), 364-368.

Severino LS, Auld DL, Baldanzi M, et al. A review on the challenges for increased production of castor. Agron J. 2012;104(4):853

Singh, S., Sharma, S., Sarma, S. J., & Brar, S. K. (2023). A comprehensive review of castor oil-derived renewable and sustainable industrial products. *Environmental Progress & Sustainable Energy*, *42*(2), e14008.

Xu, F., Wang, S., Kong, R., & Wang, C. (2023). Synergistic effects of dodecane-castor oil acid mixture on the flotation responses of low-rank coal: A combined simulation and experimental study. *International Journal of Mining Science and Technology*, *33*(5), 649-658.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

PRODUCTION OF CYBRIDS IN PLANTS

Article ID: AG-VO4-I12-110

[1]V. B. Divyadarshini, V. B., [2*]V. Krishnan., [1]P. Sowmiya, [1]A. Shivada, [1]Adavi Lakshmi Nikhil and [1]C. S. Subash Chandra Bose

[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India

*Corresponding Author Email ID: anurathakrishnan66@gmail.com

Introduction

In sexual hybridization the plastid and mitochondrial genomes are generally contributed by only the female parent whereas in somatic hybridization the extranuclear genomes from both the parents are combined. Consequently, the latter approach to crossing plants offers a unique opportunity to study the interaction of the cytoplasmic organelles. Interparental recombination of mitochondrial genomes and independent assortment of chloroplasts and mitochondria following cell fusion results in plants with novel combinations of nuclear/plastid/mitochondria genomes. A plant having nuclear genome mostly derived from one of the fusion partners with at least some alien organelle genome, derived from the other fusion partner, is termed cybrid. Some of the desirable traits, such as cytoplasmic male sterility (CMS), certain types of disease resistance and herbicide resistance are encoded in extranuclear genomes.

Sexual hybridization is a precise mixture of parental nuclear genes but the cytoplasm is derived from the maternal parent only, while in somatic hybrids the cytoplasm is derived from both the parents. However, somatic hybrids can be obtained where nucleus is derived from one parent and cytoplasm is derived from both, thus producing cytoplasmic hybrids, also called as cybrids. Alloplasmic lines, with nucleus of one parent in the cytoplasm of another parent are conventionally obtained by crossing the two parents with the cytoplasm-donor (hereafter called 'donor') as the female parent, followed by a series of backcrossing with cytoplasm recipient (hereafter, called 'recipient') parent as the recurrent pollinator. Moreover, this approach does not allow combining two cytoplasmically controlled traits occurring in different plants. By cell fusion, on the other hand, cybrids can be produced in a single manipulation, and it is an efficient method to transfer cytoplasmic characters from one parent to the other or combining cytoplasmic characters from two parents.

HISTORY OF CYBRIDS

In 1892 Klercker was the first to isolate protoplast from *Stratiotes aloides* using mechanical method. Cocking in 1960 was the first to report the isolation of protoplast from tomato root tips using concentrated solutions of cellulase from the fungus *Myrothecium verrucosa.* Enzymes for protoplast isolation was first employed by Takebe and his co-workers in 1968. Kao and Michayluk in 1974 first proposed PEG for fusion of protoplast. Gleba 1979 fused tobacco protoplast which produced a cybrid. Melchers and Labib in 1974 fused protoplast of two haploid light sensitive lines of *Nicotiana tabacum*. Kao and Wetter in 1976 isolated cell cybrids of *Glycine max* and *Nicotiana glauca*. Pental and Cocking proposed that triploids could be produces by fusing protoplast isolated from microspores at the tetrad stage (n) of a species with protoplast isolated from the somatic cells of other species. Pirrie and Power synthesized triploids by fusing microspore protoplast of *Nictotiana glutinosa* with somatic cell protoplast of *Nicotiana tabacum*.

CYBRID - DEFINITION

Cybrids are cell or plants containing nucleus of one species but cytoplasm from both the parental species. The process of protoplast fusion resulting in the development of cybrid is known as cybridization. It is created by using a cell that serves as a nuclear donor with a cytoplast from a different source, serving as a mitochondrial donor. It contains the nuclear and cytoplasmic genome of one parent and the only cytoplasmic genome of the second one. It is also known as hybridization. Cybrids are produced during fusion of protoplast from two phylogenetically distant species. Regeneration from phylogenetically distant species will have plastomes from both parental species but the functional genome of only one species through chromosomal elimination. The extranuclear genes which control agronomically important characters are of considerable interest. In cytoplasmic hybridization, nucleus from one protoplast is inactivated or segregated out in early stage such that one protoplast contributes the cytoplasm while the other contributes the nucleus alone or both nucleus and cytoplasm.

There are different ways of inactivating the nucleus of one protoplast. In cybrids, there is fusion between protoplasts containing the full component of nucleus, mitochondria and chloroplasts with functional cytoplasmic component of second protoplast.

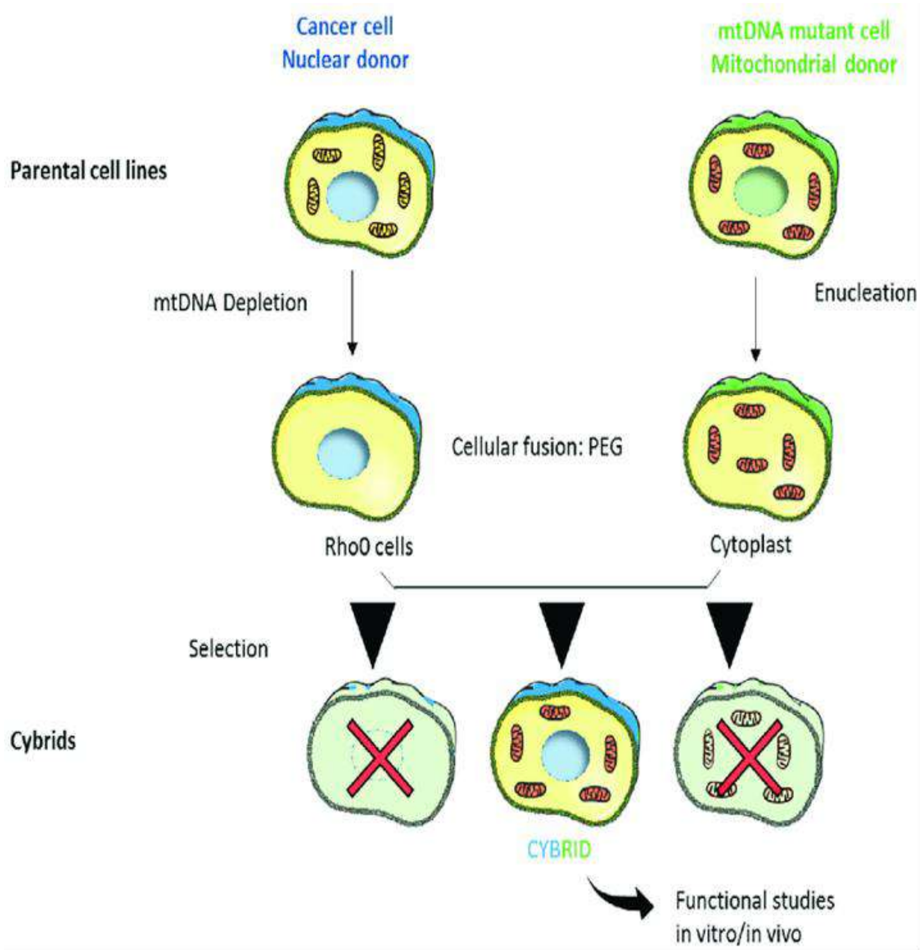


Fig. 1. Production of Cybrids

DIFFERENT WAYS TO PRODUCE CYBRIDS

There are four different ways of cybrid production *viz*.,

1. By application of lethal dosages of X-rays or gamma rays to one parental protoplast population:

Ionizing radiation treatment damages the nucleus, thus the protoplasts become inactivated and non-dividing but they function as an efficient donor of cytoplasmic genophores when fused with recipient protoplasts. *Nicotiana* protoplasts can be inactivated by 5-kr dose of X-rays. Other protoplasts may require different doses.

2. By treatment with iodoacetate to metabolically inactivate the protoplasts:

Pre-treatment with iodoacetate will cause the degeneration of non-fused and auto-fused protoplasts while fusion of iodoacetate pre-treated protoplasts with non-treated protoplasts will cause metabolic complementation and result in viable hybrids.

3. **Fusion of normal protoplasts with enucleated protoplasts:**

The high-speed centrifugation (20,000–40,000x g) for 45–90 minutes in an iso-osmotic density gradient with 5–50% percoll will yield enucleated protoplasts. Additional exposure of isolated protoplasts to **cytochalsin B** in combination with centrifugation has also been found beneficial for enucleation.

4. Fusion of cytoplasts with protoplasts:

Isolated protoplasts can be experimentally induced to fragment into types of sub-protoplasts called mini-protoplasts or cytoplasts. The term mini-protoplast was coined by Wallin et al. (1978) for sub-protoplasts having nuclear material which can divide and may be able to regenerate into plants. The other similar terms for mini-protoplasts are karyoplast (evacuolated sub-protoplast) or nucleoprotoplast. The nuclear free subprotoplasts which donot divide but are important in the process of cybridization are termed as cytoplasts.

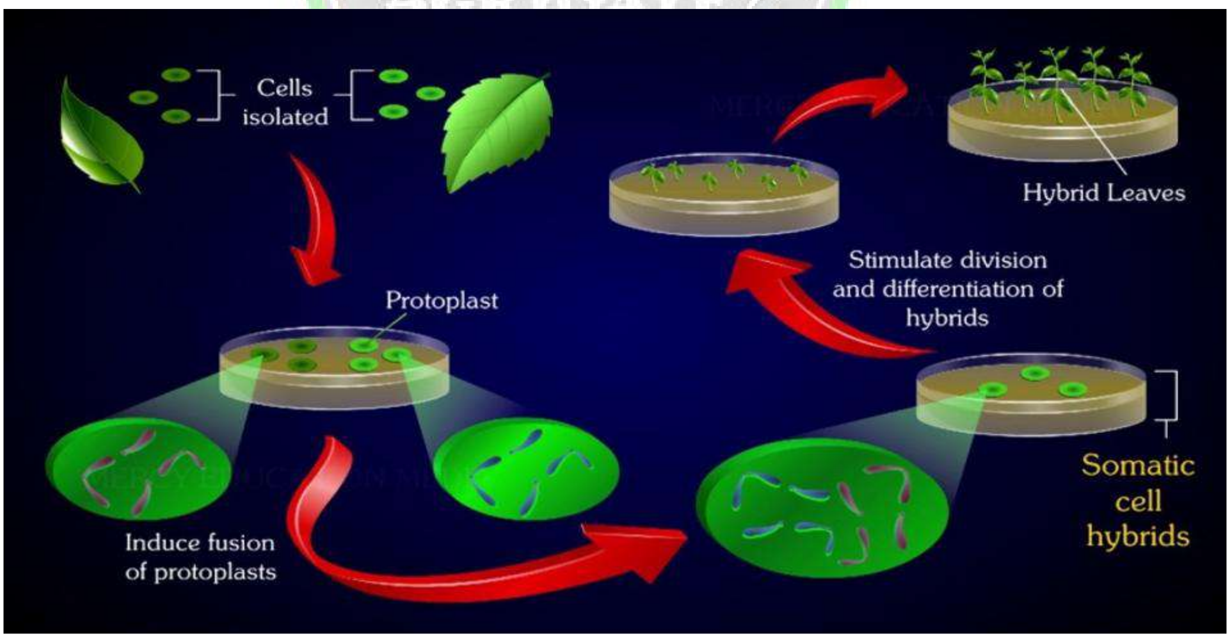


Fig. 2. Flow diagram of Cybrid production

APPLICATION OF CYBRIDS

1. Production of hybrid organisms
2. Overcomes sexual incompatibility barriers
3. Somatic hybridization for gene transfer
4. Transfer of Cytoplasmic male sterility
5. Production of resistant variety using cytoplasmic genes
6. Production of auto-tetraploids using Colchicine from cybrids
7. For genetic study of cytoplasmic genes
8. Production of unique nuclear-cytoplasmic combinations

LIMITATIONS OF CYBRIDS

1. Cybrids are often sterile, deformed, and unstable and are thus not viable, particularly if the fusion partners are taxonomically far apart.
2. Protoplasts from any two species can be fused. However, production of somatic hybrid plants has been limited to a few species only.
3. Lack of an efficient selection method for fused product.
4. Development of chimeric calluses in place of hybrids due to the nuclei not fusing after cell fusion and dividing separately.
5. Somatic hybridization of two diploids leads to the formation of an amphidiploid which is generally unfavourable.
6. Regeneration products after somatic hybridization are usually variable due to somaclonal variation that arise.
7. It is never certain that a particular characteristic will be expressed after somatic hybridization.
8. The genetic stability during protoplast culture is poor.
9. Most of the cybrids are incapable of sexual reproduction, which is a must plant breeding.
10. Cybrids containing a mixture of genes from two species must be backcrossed to the cultivated crop to develop new varieties.

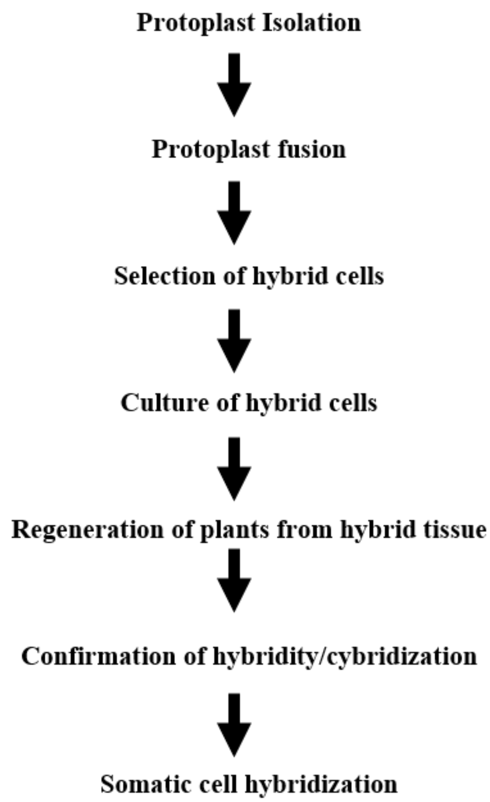


Fig. 3. Flow chart for Cybrid production

Conclusion

Somatic hybridization has evolved from the academic stage to field applications, making it a promising method for introducing foreign genes, such as polygenic characteristics, into crop plants. Somatic hybridization has the unique ability to combine different nuclear and/or cytoplasmic organelles, which increases the gene pool's diversity. Prior to plant regeneration, the nuclear genome of one of the parents may be partially or entirely destroyed throughout subsequent cell cycles, resulting in the creation of an asymmetric hybrid or cybrid, respectively. The impact of somatic hybridization has been greatly increased by asymmetric somatic hybridization, which transfers a portion of the donor parent's gene, and by cybridization, which transfers cytoplasmic features. Furthermore, it is well known that protoplast fusion can be exploited to produce valuable bridging material for breeding schemes.

References

Bravo, J. E., & Evans, D. A. (1985). Protoplast fusion for crop improvement. *Plant breeding reviews*, *3*, 193-218.

Evans, D. A. (1983). Agricultural applications of plant protoplast fusion. *Bio/technology*, *1*(3), 253-261.

Galun, E., & Aviv, D. (1991). Cybrid production and selection. In *Plant Tissue Culture Manual: Supplement 7* (pp. 657-673). Dordrecht: Springer Netherlands.

Guo, W. W., Cai, X. D., & Grosser, J. W. (2004). Somatic cell cybrids and hybrids in plant improvement. In *Molecular biology and biotechnology of plant organelles: chloroplasts and mitochondria* (pp. 635-659). Dordrecht: Springer Netherlands.

Pelletier, G., Vedel, F., & Belliard, G. (1985). Cybrids in genetics and breeding. *Hereditas*, *103*, 49-56.

Seeja, G., & Sreekumar, S. (2020). A review on cybrids: An approach for plant improvement. *Crop Research*, *55*(1and2), 48-56.

CALLING ALL FUTURE FARMERS

Expressions of Interest are open for

GRAEME SMITH'S PROTECTED CROPPING MASTERCLASS

BENGALURU & HYDERABAD, FEBRUARY 2025

Greenhouses, polyhouses, hydroponics, aquaponics, vertical farming, agritech, and automation- this is the definitive training course for future farming, delivered by internationally experienced

GRAEME SMITH CONSULTING (CPAG) - HYDROPONIC CONSULTANCY SERVICES

For registration →

ENROLMENT PRICE

Standard: ~~₹60,000~~ + GST

Early Bird: ₹50,000 +GST

← For brochure

Biogrow customers will get 10% discount for any ticket price.
Discount offers available for bulk ticket purchase

FOR ENQUIRIES

Our Contact
+91 8123752506

Mail ID
sara.nour@bio-grow.com

Volume: 04 Issue No: 12

ROLE OF MICROALGAE IN AQUACULTURE SECTOR

Article ID: AG-V04-I12-111

Gobi Gunasekaran[a]*, S A Raj Vasanth[b], R Dinesh[c] and V Ranjithkumar[a]

[a]Dr. M.G.R. Fisheries College and Research Institute, Ponneri, Tamil Nadu, India

[b]Fisheries College and Research Institute, Thoothukudi, Tamil Nadu, India.

[c]Central Institute of Fisheries Education, Mumbai, Maharashtra.

*Corresponding Author Email ID: gobimfsc@gmail.com

Abstract

Microalgae play a vital role in the aquaculture sector, offering a sustainable solution for enhancing productivity and maintaining environmental balance. It provides essential nutrients, including proteins, lipids, vitamins, and carotenoids, making them a key feed source for fish, shrimp, and mollusc larvae. Their unique properties such as high nutritional value, rapid growth rates and adaptability to various culture conditions indispensable in aquaculture hatcheries. Their dual functionality supports sustainable practices by reducing environmental impacts and promoting healthy growth in aquatic species. Furthermore, the use of microalgae in aquaculture sector aligns with global efforts to develop cost-effective and eco-friendly alternatives to conventional feed ingredients, such as fishmeal and fish oil.

Keywords: Aquaculture. Microalgae. Aquafeed. Nutrition. Sustainability.

Introduction

Algae are photosynthetic organisms that serve as the primary source of cellular carbon and chemical energy for other organisms. Consequently, they were usually referred to as primary producers. They are classified as macroalgae (seaweed) and microalgae (unicellular). (Velichkova et al. 2012). Microalgae require light, carbon dioxide, and nutrients to grow optimally. Microalgae have been produced and used for food, for the producing of valuable compounds, as biofilters to remove nutrients and other pollutants from wastewater, in the cosmetic and pharmaceutical sectors, and for aquaculture (Sharma et al., 2013). Also, microalgae are potentially viable sources for biofuel production because of their high oil content and prone biomass production (Hattab et al., 2014).

The aquaculture sector is developing three times faster than the terrestrial animal production industry over the past thirty years. The key applications of microalgae in aquaculture are mostly related to their nutritional significance (Jyothi, 2017). Microalgae species must meet a variety of criteria, including ease of cultivation, absence of toxicity, high nutritional value with appropriate cell size and shape, and a digestible cell wall to make nutrients available (Raja et al. 2004; Patil et al. 2007). They are commonly used as live feed in hatcheries to ensure that fish and shrimp larvae survival. As well as nourishing the larval stages of oysters, clams, abalone, and mussels. The most often applied microalgae in the aquaculture industry includes *Chlorella, Scenedesmus, Chaetoceros, Nannochloropsis, Tetraselmis, Pavlova, Phaeodactylum, Skeletonema* and *Thalassiosira*. Because they grow promptly and remains stable in a variety of hatchery culture circumstances (Brown et al., 2002).

Microalgae are used in aquaculture hatcheries to generate and maintain water quality (Spolaore et al., 2006). Waste water from extensive fish farms accumulates with solid particles and dissolved nutrients, primarily inorganic nitrogen and phosphorus. The application of live microalgae to remove excess dissolved nutrients from aquaculture effluents. It is an effective and economical waste water treatment approach (Velichkova et al., 2014). In recent years, the notion of employing microalgae in aquaculture has been developed, and significant efforts are being made to promote the industrial implementation of microalgae-assisted aquaculture. This article will discuss the production and usage of microalgae as larval feed, as well as its significance in the aquaculture sector.

Microalgae as aquafeed

The growing demand for protein and the rising cost of fishmeal have driven the search for alternative protein sources from both animal and plant origins for aquaculture (Sirakov et al., 2015). Microalgae show great potential as a source of protein, lipids, vitamins, carotenoids, and energy in aquafeeds. During the late logarithmic growth phase, microalgae typically contain 30–40% protein, 10–20% lipids, and 5–15% carbohydrates (Brown et al. 1997).

Incorporating microalgae into aquafeeds offers numerous benefits, such as improving the growth rate of aquatic species through increased muscle triglyceride and protein deposition, enhancing disease resistance, reducing nitrogen waste output, and providing omega-3 fatty acids (Becker 2004).

These qualities make microalgae a promising alternative to traditional feed ingredients. However, their high production costs remain a significant challenge for replacing fishmeal and fish oil on a large scale (Becker 2007). Using a combination of different microalgal species in feed can provide a more balanced nutritional profile and enhance fish growth more effectively than relying on a single species (Patil *et al*. 2007).

Table. 1. Most commonly used microalgae species in Aquaculture hatcheries

Application in aquaculture sector	Commonly used microalgae species
In formulated feed ingredient	Arthrospira platensis (Cyanophyceae); Chlorella vulgaris, C.minutissima, C.virginica, Dunaliella tertiolecta, D. salina, Haematococcus pluvialis (Chlorophyceae)
Feed for bivalve mollusks	Thalassiosira pseudonana (Bacillariophyta); Pavlova lutheri (Haptophyta); Isochrysis galbana , Chlorella minutissima, , Isochrysis galbana, Nitzschia sp, Phaeodactylum tricornutum, Tetraselmis suecica, T.chui (Chlorophyceae); Chaetoceros calcitrans,C. gracilis; Skeletonema costatum.
Rotifer and Artemia	Crypthecodinium cohnii (dinoflagellates); Schizochytrium sp.; Chlorella sp, Chlamydomonas sp, Nannochloropsis oculata, Tetraselmis tetrathele and T. chuii.
Feed for crustacean larvae	Tetraselmis suecica, T.chui (Chlorophyceae); Chaetoceros calcitrans, gracilis; Skeletonema costatum; Thalassiosira pseudonana (Bacillariophyta).
Feed for gastropod molluscs and sea urchins	Nitzschia sp; Navicula sp.; Amphora sp.
Green water for finfish larvae	Chlorella vulgaris; Isochrysis galbana; Nannochloropsis oculata

(Jyothi et al., 2018)

Microalgal protein and lipids

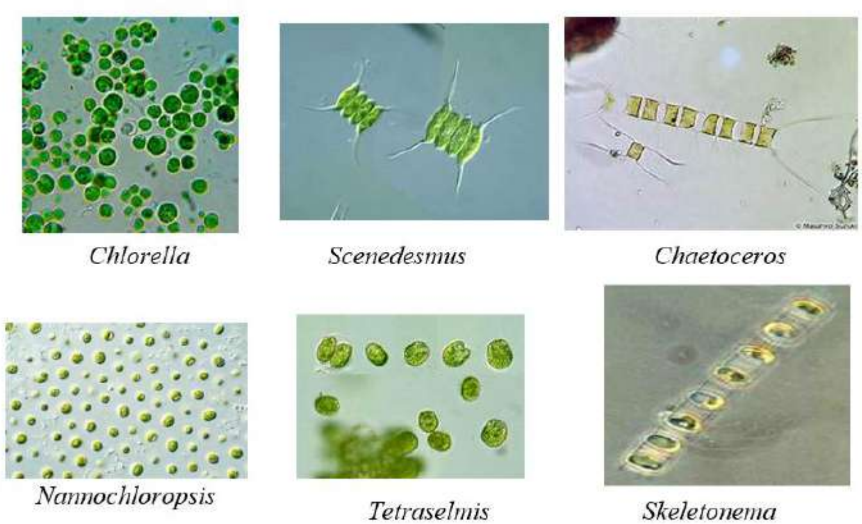
Microalgal protein is a promising alternative to fishmeal protein due to its high quality and balanced amino acid profile (Becker 2007). Compared to soybean protein, microalgae offer much higher productivity, making them a viable protein source for aquaculture. Studies have shown that fish fed with microalgae-based diets exhibit a better feed conversion ratio (FCR) than those fed with traditional feed (Li et al., 2014).

Microalgal lipids are rich in polyunsaturated fatty acids (PUFAs), including DHA (found in *Crypthecodinium* and *Schizochytrium*), EPA (present in *Nannochloropsis*, *Phaeodactylum*, *Nitzschia*, *Isochrysis*, and *Diacronema*), and ARA (*Porphyridium*) (Brown 2002). These fatty acids, particularly EPA and DHA, are essential for the growth and survival of marine fish larvae. Oils extracted from microalgae such as *Isochrysis*, *Nannochloropsis*, *Phaeodactylum*, *Pavlova*, and *Thalassiosira* are rich in omega-3 long-chain PUFAs, making them a sustainable alternative to fish oil (Ryckebosch et al. 2014).

Microalgal pigments

Microalgae pigments play a crucial role in enhancing their nutritional value in aquaculture. *Nannochloropsis sp.* is a notable source of pigments like chlorophyll a, zeaxanthin, canthaxanthin, and astaxanthin. Similarly, *Phaeodactylum sp.* is rich in fucoxanthin, carotene, chlorophyll a, and chlorophyll c (Brown et al. 1997). *Haematococcus pluvialis* is the primary source of astaxanthin, which gives salmon their distinctive pink muscle color (Ambati et al. 2014).

Commonly used microalgae species in Aquaculture sector



Carotenoids derived from microalgae are widely used as natural feed colorants, feed additives, vitamin supplements, and in health products. *Dunaliella salina* is particularly valuable for large-scale production due to its ability to accumulate carotenoids, reaching up to 14% of its dry weight (Borowitzka 2013b). Lutein, an essential carotenoid found in foods and human serum, is commonly used as a food colorant and as a feed additive in aquaculture (Lorenz and Cysewski 2000).

Microalgae as immunostimulants

Microalgae play an expanding role in aquaculture, serving as potential immunostimulants for commercially important species. For instance, microalgae can enhance the survival rate and immune system of shrimp larvae. *Chlorella* has shown promise as a feed additive, improving growth, physiological performance, and both innate and adaptive immunity in gibel carp (*Carassius auratus gibelio*) (Xu et al. 2014).

Euglena viridis boosts the immune response in Rohu *(Labeo rohita)*, helping protect against bacterial infections like *Aeromonas hydrophila* by increasing lysozyme levels, serum bactericidal activity, and superoxide anion production (Das et al. 2009). Similarly, *Dunaliella salina* enhances immune and antioxidant defenses, such as superoxide dismutase and catalase, improving the survival rate of shrimp (*Penaeus monodon*) infected with white spot syndrome virus (Madhumathi and Rengasamy 2011).

Current challenges

The high production cost of microalgae remains a significant challenge for its widespread use in aquaculture. To make microalgae economically viable, it is crucial to lower production costs and scale up production effectively. Poor drying techniques can negatively impact their nutritional and physical properties, reducing their value as feed. Additionally, marine microalgae may pose issues such as low digestibility and excessive salt accumulation. Depending on growth and processing conditions, microalgae biomass may also contain high levels of trace elements and toxins, limiting its suitability for aquafeeds.

Conclusion

Microalgae have significant potential in aquaculture as a sustainable alternative to fishmeal and fish oil in fish feeds. However, more well-designed feeding trials are needed to fully evaluate their effectiveness. With advancements in producing microalgal biomass that is both nutrient-rich and cost-effective, the aquafeed industry can become more sustainable. This would enable the aquaculture sector to continue growing and meet current and future demands reliably.

References

Al-Hattab, M., & Ghaly, A. (2014). Effects of light exposure and nitrogen source on the production of oil from freshwater and marine water microalgae.

Ambati, R. R., Phang, S. M., Ravi, S., & Aswathanarayana, R. G. (2014). Astaxanthin: Sources, extraction, stability, biological activities and its commercial applications—A review. *Marine drugs*, *12*(1), 128-152.

Becker E (2007) Micro-algae as a source of protein. *Biotechnol Adv* 25: 207–210.

Becker W (2004) Microalgae in human and animal nutrition. In: Richmond A (ed) Handbook of microalgal culture: *biotechnology and applied phycology*. Blackwell Science Ltd, Cambridge, pp 312–351

Borowitzka, M. A. (2013). Dunaliella: biology, production, and markets. *Handbook of microalgal culture: applied phycology and biotechnology*, 359-368.

Brown, M. R. (2002). Nutritional value and use of microalgae in aquaculture. *Avances en Nutrición Acuicola*.

Brown, M. R., Jeffrey, S. W., Volkman, J. K., & Dunstan, G. A. (1997). Nutritional properties of microalgae for mariculture. *Aquaculture*, *151*(1-4), 315-331.

Das, B. K., Pradhan, J., & Sahu, S. (2009). The effect of *Euglena viridis* on immune response of rohu, *Labeo rohita* (Ham.). *Fish & Shellfish Immunology*, *26*(6), 871-876.

Kaparapu, J. (2017). Algae in formulated feeds, J. *Algal Biomass Util*, *8*, 23-28.

Kaparapu, J. (2018). Application of microalgae in aquaculture. *Phykos*, *48*(1), 21-26.

Li, M., Wu, W., Zhou, P., Xie, F., Zhou, Q., & Mai, K. (2014). Comparison effect of dietary astaxanthin and *Haematococcus pluvialis* on growth performance, antioxidant status and immune response of large yellow croaker *Pseudosciaena crocea*. *Aquaculture*, *434*, 227-232.

Lorenz, R. T., & Cysewski, G. R. (2000). Commercial potential for *Haematococcus* microalgae as a natural source of astaxanthin. *Trends in biotechnology*, *18*(4), 160-167.

Madhumathi, M., & Rengasamy, R. (2011). Antioxidant status of *Penaeus monodon* fed with *Dunaliella salina* supplemented diet and resistance against WSSV. *Int. J. Eng. Sci. Technol*, *3*(10), 7249-7259.

Patil, V., Källqvist, T., Olsen, E., Vogt, G., & Gislerød, H. R. (2007). Fatty acid composition of 12 microalgae for possible use in aquaculture feed. *Aquaculture International*, *15*, 1-9.

Raja, R., Anbazhagan, C., Lakshmi, D., & Rengasamy, R. (2004). Nutritional studies on *Dunaliella salina* (Volvocales, Chlorophyta) under laboratory conditions. *Seaweed Resources Utilization*, *26*, 127-146.

Ryckebosch, E., Bruneel, C., Termote-Verhalle, R., Goiris, K., Muylaert, K., & Foubert, I. (2014). Nutritional evaluation of microalgae oils rich in omega-3 long chain polyunsaturated fatty acids as an alternative for fish oil. *Food chemistry*, *160*, 393-400.

Sharma, P., Khetmalas, M. B., & Tandon, G. D. (2013). Biofuels from green microalgae. *Biotechnology: prospects and applications*, 95-112.

Sirakov, I., Velichkova, K., Stoyanova, S., & Staykov, Y. (2015). The importance of microalgae for aquaculture industry. Review. *Int J Fish Aquat Stud*, *2*(4), 81-84.

Spolaore, P., Joannis-Cassan, C., Duran, E., & Isambert, A. (2006). Commercial applications of microalgae. *Journal of bioscience and bioengineering*, *101*(2), 87-96.

Velichkova K, Sirakov I & Georgiev G. (2012). Cultivation of *Botryococcus braunii* strain in relation of its use for biodiesel production. *J Bio Sci Biotech* SE/ONLINE, 157-162.

Velichkova, K., Sirakov, I., & Stoyanova, S. (2014). Biomass production and wastewater treatment from aquaculture with *Chlorella vulgaris* under different carbon sources.

Xu, W., Gao, Z., Qi, Z., Qiu, M., Peng, J. Q., & Shao, R. (2014). Effect of dietary *Chlorella* on the growth performance and physiological parameters of gibel carp, *Carassius auratus gibelio*. *Turkish Journal of Fisheries and Aquatic Sciences*, *14*(1).

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

Article ID: AG-V04-I12-112

SOMACLONAL VARIATION AND GAMETOCLONAL VARIATION IN TISSUE CULTURE

[1]Sowmiya, P., [2*]V. Krishnan., [1]A. Shivada, [1]Adavi Lakshmi Nikhil,
[1]C. S. Subash Chandra Bose and [1]V. B. Divyadarshini,
[1]PG Scholar & [2]Faculty, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal 609603, U. T. of Puducherry, India
*Corresponding Author Email ID: anurathakrishnan66@gmail.com

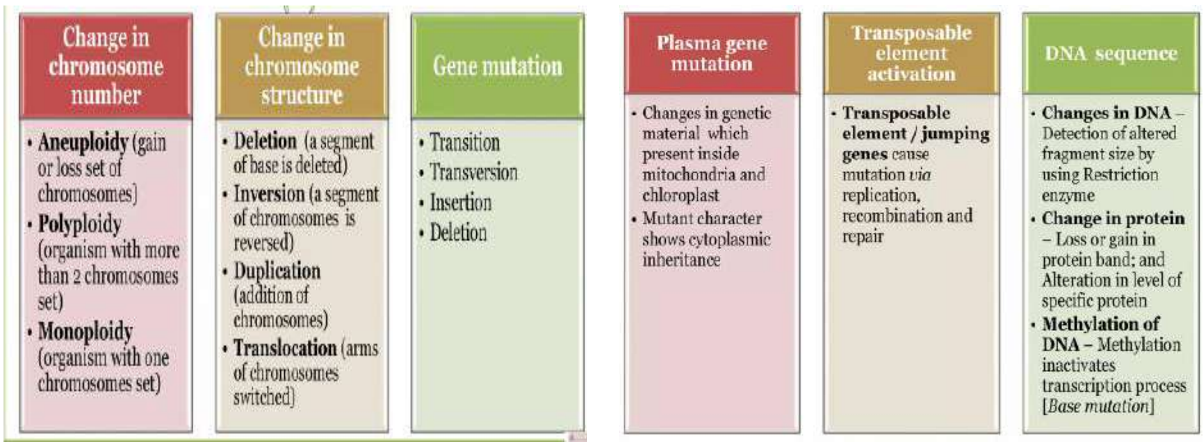
Introduction

Variants obtained using callus cultures are referred as "Calliclones" (Skirvin, 1978) while variants obtained using protoplast cultures are known as "Protoclones" (Shepard et al. 1980). Larkin and Scowcroft (1981) proposed a general term 'Somaclonal variation' to describe genetic variation in plants regenerated from any form of cell cultures. Accordingly, the plants derived from cell and tissue cultures are termed as 'somaclones', and the plants displaying variation as 'somaclonal variants'. Another term suggested by Evans et al. (1984) as 'gametoclonal variation' for those variations arising in cell cultures of gametic origin like, in pollen and microspores cultures, to distinguish them from somatic cell derived regenerants. However, generally the term somaclonal variation is used for genetic variability present among all kinds of cell/plants obtained from cell cultures *in vitro*. Plants regenerated from tissue and cell cultures show heritable variation for both qualitative and quantitative traits. It may occur spontaneously during repeated subcultures or due to induced mutations.

FACTORS CAUSING SOMOCLONAL VARIATIONS

Somaclonal variations occur as a result of genetic and non-genetic factors in plant tissue cultures.

A. Genetic factors: Chromosome structure, Chromosome number, Mitotic crossing over, Cytoplasmic genetic changes, DNA-methylation, Transposable elements, Nuclear changes.



B. Non-genetic factors:

1. **Nature of explant:** The nature of genotype of the plants influences the frequency of regeneration and frequency of production of somaclones. Explants can be taken from any part of plant - leaves, roots, internodes, ovaries etc. The source of explant is very critical for somaclonal variations.
2. **Duration of cell culture:** In general, for many plant cultures, somaclonal variations are higher with increased duration of cultures. For example, it was reported that genetic variability increased in tobacco protoplasts from 1.5 to 6% by doubling the duration of cultures.
3. **Growth hormone effects:** The plant growth regulators in the medium will influence the karyotypic alterations in cultured cells, and therefore development of somaclones. Growth hormones such as 2, 4-dichlorophenoxy acetic acid (2, 4-D) and naphthalene acetic acid (NAA) are frequently used to achieve chromosomal variability.
4. **Culture Condition:** It has been known that growth regulator composition of the culture medium can influence frequently of karyotypic attention in cultured cells.

APPLICATIONS OF SOMOCLONAL VARIATIONS

i. **Production of Novel variants:** An implication of somaclonal variation in breeding is that novel variants can arise and these can be agronomically used. A number of breeding lines have been developed by somaclonal variation. Example: Development of pure thornless blackberries.

ii. Distinctive mutations may sometimes give rise to elite characters in the regenerants which cannot be achieved by conventional methods of breeding.

iii. **Seed quality improvement: -** Recently, a variety Bio L 212 of lathyrus (*Lathyrus* sativa) has been identified for cultivation in central India which has been developed through somaclonal variation and has low ODAP (β-N-oxalyl -2-α, β diamino propionic acid), a neurotoxin indicating the potential of somaclonal variations for the development of varieties with improved seed quality.

iv. **Production of Drought tolerance:** - Drought tolerant rice lines were obtained by in vitro selection of seed induced callus on a media containing polyethylene glycol as a selective agent which stimulated the effect of drought in tissue culture conditions.

v. **Production of Salt tolerance:** - Plant tissue culture techniques have been successfully used to obtain salt tolerant cell lines or variants in several plant species like tobacco, alfalfa, rice, maize, brinjal, sorghum, etc. In most cases, the development of cellular salt tolerance has been a barrier for successful plant regeneration, or if plants have been obtained, they did not inherit the salt tolerance.

vi. **Production of Aluminium tolerance:** -Plant species or cultivars greatly differ in their resistance to aluminium stress. In recent years, considerable research has been focused on the understanding of physiological, genetic and molecular processes that lead to aluminium tolerance.

vii. **Production of Herbicide resistance:** Through *in vitro* selection several cell lines resistant to herbicides have been isolated and a few have been regenerated.

Crop	Common name	Herbicide
Glycine max	Soybean	Imazethapyr
Nicotina tabacum	Tobacco	Glyphosate
Gossypium hirsutum	Cotton	Sulfonylurea, Imidazolinone
Zea mays	Maize	Sethoxydim, Cycloxydim
Zea mays	Maize	Glyphosate
Triticum aestivum	Wheat	Difenzoquat
Beta vulgaris	Beet	Imidazolinone
Datura innoxia	Sacred datura	Chlorosulfuron

viii. **Production of Cold tolerance:** Azar et al. (1988) developed somoclonal variants for freezing tolerance in Norstar winter wheat. A significant positive correlation between proline level and frost tolerance has been found in a broad spectrum of genotypes. *In vitro* selection and regeneration of hydroxyproline resistant lines of winter wheat with increased frost tolerance and increased proline content has been reported. The results showed strong correlation of increased frost tolerance with increased proline content.

EXAMPLES OF SOMACLONAL VARIATIONS:

1. Rice-Number of tillers per plant, fertile tillers per plant, panicle length, plant height, early maturity, seed fertility, disease resistance, drought tolerance and cold tolerance.
2. Wheat-Plant height, awns, tiller number. grain colour, spike shape, gliadin protein, maturity, leaf wax, amylase, temperature tolerance and disease resistance.
3. Maize-Plant height, node number, ear arrangement, stalk number, toxin resistance, mitochondrial pattern, etc.
4. Brassica-Flowering time, plant height, leaf wax and disease resistance.
5. Tobacco-Plant height, leaf size, alkaloid content
6. Tomato-Disease resistant and early maturity.
7. Sugarcane-Sugar content, auricle length, disease resistance and early maturity.
8. Potato-High protein content, early maturity, resistance to viruses and *Phytophthora*
9. Legumes-Resistance to pod borer, *Fusarium* wilt.
10. Groundnut-Shallow depth of pod development, induction of dormancy, resistance to *Fusarium* and *Aspergillus*
11. Sunflower-Self compatibility, resistance to *Alternaria* blight, *Rhizoctonia* and *Fusarium*.

GENETIC ANALYSIS OF SOMACLONAL VARIATIONS

Most useful somaclones are those which carry almost all of the good parental characters as well as incorporate within it certain desirable characters which were lacking in its parents. It becomes extremely important to select variants as early as possible, with minimal exposure of cells to tissue culture environment. With prolonged culture gross abnormalities may appear. The variants are generally assessed at the phenotypic level, and in over 50% cases it is based on R0 plants. However, this approach of screening R0 plants would the screening of only homozygous or dominant traits. The recessive mutations in heterozygous regenerants can be recognized only in the segregating R1 and R2 progenies. It is, therefore, important that the variants should be assessed in the sexual progenies of the *in vitro* regenerated plants. So, that their heritability is established. The effect of environment on the phenotype of plant can also be detected using biochemical characterization mostly involving protein electrophoresis. These above-mentioned methods can be very well used for the assessment of phenotypic variations but the variation or change at genome level cannot be monitored. In order to detect the variation at DNA level, use of certain molecular markers is encouraged. RFLP appears to be a better technique as it helps in identifying slight changes and also in studying plants grown in different environments.

LIMITATIONS OF SOMOCLONAL VARIATIONS:

i. Poor plant regeneration from long-term cultures of various cell lines.

ii. Regeneration being limited to specific genotypes which may not be of much interest to breeders.

iii. Some somaclones have undesirable features, such as aneuploidy, sterility etc.

iv. Unpredictable variations that are often generated are of no use. Variations attained may not always be stably integrated.

v. Variants attained may not always be novel. In majority of cases improved variants are not even selected for breeding programs.

vi. Uncontrollable and unpredictable nature of variation and most of the variations are of no apparent use it. The variation is cultivar dependent.

vii. The variation obtained is not always stable and heritable. The changes occur at variable frequencies.

ISOLATION OF SOMACLONAL VARIATION *VIA* 2 SCHEMES:

1. Without *in-vitro* selection
2. With *in-vitro* selection

WITHOUT *IN-VITRO* TECHNIQUE:

- Unorganized callus and cells, grown in cultures for various periods on a medium that contain no selective agents, are induced to differentiate whole plants.
- An explant is cultivated on a suitable medium supplemented with grown regulators.
- The unorganized callus and cells do not contain any selective agent toxic or inhibitory substance.
- These cultures are normally sub cultured and transferred to shoot induction medium for regeneration of plants.
- The so produced plants are grown in pots, transferred to field, and analysed for somaclonal variants.

A list of disease resistant crop plants obtained by somaclones at the plant level without *in-vitro* selection

Crop	Pathogenic organism(s)
Rice	*Helminthosporium oryzae*
Maize	*Helminthosporium maydis*
Barley	*Rhynchosporium secalis*
Sugarcane	*Puccinia melanocephala, Sclerospora saccharii, Helminthosporium sacchari*
Potato	*Streptomyces scabie, Alternaria solani, Phytophthora infestans, Potato virus X and Y*
Tomato	*Pseudomonas solanacearum, Fusarium oxysporum*
Tobacco	*Phytophthora parasitica*
Apple	*Phytophthora cactorum*
Banana	*Fusarium oxysporum*
Lettuce	*Lettuce mosaic virus*
Alfalfa	*Fusarium solanii, Verticillium albo-atrum*

A list of disease resistant crop plants obtained by with *in-vitro* selection

Crop	Pathogenic organism(s)	Selection agent
Rice	*Helminthosporium oryzae, Xanthomonas oryzae*	Crude toxin Bacterial cells
Maize	*Helminthosporium maydis*	Hm T toxin
Wheat	*Helminthosporium sativum, Pseudomonas syringae*	Crude toxin Syringomycin
Barley	*Helminthosporium sativum, Fusarium spp.*	Crude toxin Fusaric acid
Sugar-cane	*Helminthosporium sacchari*	Toxin
Potato	*Phytophthora infestans, Fusarium oxysporum, Erwinia carotovora*	Crude filtrate Crude filtrate Pathogen
Tomato	*Pseudomonas solanacearum, tobacco mosaic virus X*	Crude filtrate Virus
Tobacco	*Phytophthora syringae, Pseudomonas syrinae*	Toxin Methionine sulfoximine
Alfalfa	*Fusarium oxysporum*	Crude filtrate

Limitations of Without *in-vitro* selection:

- ✓ No specific approach for isolation of somaclones.
- ✓ Appearance of desired traits are purely by chance.
- ✓ Time consuming procedure.

WITH *IN-VITRO* TECHNIQUE:

- ➢ Cells lines are analysed from plant cultures for their capability to survive in the presence of a toxic substance in medium or under environmental stress conditions.
- ➢ The differenciated callus obtained from an explant any cells, protoplast or calli is exposed in the medium to inhibitors like toxins, antibiotics, amino acid analog.
- ➢ Selection cycles are carried out to isolate the tolerant callus cultures and these calli are regenerated into plants.
- ➢ The plants so obtained are *in-vitro* screened against the toxin or pathogen or any other inhibitor.

- The plants resistant to the toxin are selected and grown further by vegetative propagation or self-pollination.
- The subsequent generations are analysed for disease resistant plants against the specific pathogenic organism.

ADVANTAGES OF WITH *IN-VITRO* SELECTION:

- ✓ Specific approach for isolation of desired trait.
- ✓ Less time consuming procedure as compare without *in-vitro* approach.

DETECTION OF SOMACLONAL VARIANTS:

I. Analysis of morphological characters
   a. Qualitative characters - plant height, maturity date, flowering date and leaf size.
   b. Quantitative characters - Yield of flowers, seeds and wax contents in different plants parts.

II. Variants detection by cytological studies - Staining of meristematic tissues like root tip, leaf tip with feulgen and acetocarmine provide the number and morphology of chromosomes.

III. Variant detection by DNA contents – Cytophotometer detection of feulgen stained nuclei can be used to measure the DNA contents.

IV. Variants detection by gel electrophoresis – Change in concentration of enzymes, proteins and chemical products like pigments, alkaloids and amino acids can be detected by their electrophoretic pattern.

V. Detection of disease resistance variant – pathogen or toxin responsible for disease resistance can be used as selection agent during culture.

VI. Detection of herbicide resistance variant – plantlets generated by the addition of herbicide to the cell culture system can be used as herbicide resistance plant.

VII. Detection of environmental stress tolerant variant:
   a. Selection of high tolerant cell lines in tobacco.
   b. Selection of water-logging and drought resistance cell lines in tomato.
   c. Selection of temperature stress tolerant in cell lines in pear.
   d. Selection of mineral toxicities tolerant in sorghum plant mainly for aluminium toxicity.

B. GAMETOCLONAL VARIATION:

The variation observed among plants regenerated from gametic cell cultures is termed as gametoclonal variation. The concept of gametoclonal variation evolved from that of somaclonal variation. Both somaclonal and gametoclonal variations were detected in cultured cells and regenerated plants for morphological, biochemical characteristics, and chromosome number and structure. The life cycle of higher plants comprises a sporophytic (2n) and a gametophytic (n) generation. For genetic reasons, it is necessary to distinguish between plants regenerated from somatic (2n, somaclones) and gametic tissues (n, gametoclones), and also between somaclonal and gametoclonal variation.

SOURCES OF GAMETOCLONAL VARIATIONS

There are four distinct sources of variations when referring to gametoclonal variation.

i. New genetic variations induced by the cell culture procedures.

ii. Variations resulting from segregation and independent assortment.

iii. New variation at the haploid level induced by the chromosome doubling, and

iv. New variation induced at the diploid level, resulting in heterozygosity.

PRODUCTION OF GAMETOCLONES:

- Gemetoclones can be developed by culturing male or female gametic cells. The cultures of anthers or isolated microspores are widely used.
- Improved have been made in several plant species through development of gametoclones. Eg: Rice Wheat and Tobaacco.

Crop	Common name	Characteristics
Oryza sativa	*Rice*	Plant height; time of flowering; seed size and protein content; level of tillering; waxy mutant; chloroplast content
Nicotiana tabacum	*Tobacco*	Plant size; leaf shape; number of leaves; alkaloid content; virus resistance; time of flowering
Brassica napus	*Rapeseed*	Leaf shape and color; time to flower; type of flower; glucinolate content; pod size and shape
Hordeum vulgare	*Barley*	Plant height; days to maturity; grain yield; fertility

Applications of Gametoclonal Variations:

- ❖ Suitable for breeding.
- ❖ Crop improvement.

- ❖ Disease, herbicides, toxin resistanc
- ❖ Abiotic rsistanc like cold, high temperature.
- ❖ Biotic resistance like insect, bacteria etc.

Conclusion

Now a days, production of somoclonal variants is one of the objectives of tissue culture. Plants differ from their parents in or free traits are called somatic variants. This variation includes aneuploids, sterile plants and morphological variants, sometimes involving traits of economic importance in case of crop plants. The usefulness of variation was first demonstrated through the recovery of disease resistant plants in potato (resistance against late blight and early blight) and sugarcane (resistance against eye-spot disease, Fiji disease and downy mildew). In addition, for the proper use of somaclonal variations, appropriate plant regeneration systems for plant species are a prerequisite for future genetic transformation, conservation, and breeding programs.

References

Anjali Singh, MS., Somaclonal Variation in Tissue Culture: Definition and causes. (2022). https://plantcelltechnology.com/blogs/blog/blogsomaclonal-variation-in-tissue-culture-definition-and-causes?srsltid=AfmBOorXClSYaVsh9ODELI78sbsK5N9M9tAoRjvKQqWRlRdlxKH6ke9p

Nataly Sanchez Del Rio. Somaclonal variation in plant tissue culture. lab associates, 10 January (2022). https://labassociates.com> somaclona-variation-in-plant-tissue-culture

Krishna, H., Alizadeh, M., Singh, D. *et al.* Somaclonal variations and their applications in horticultural crops improvement. *3 Biotech* **6**, 54 (2016). https://doi.org/10.1007/s13205-016-0389-7

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

CROP IMPROVEMENT: THE IMPORTANCE OF SPEED BREEDING IN INCREASING GENETIC GAIN

Article ID: AG-V04-I12-113

Dr.Niharika Shukla*

Scientist, Plant Breeding and Genetics, Krishi Vigyan Kendra, Jawaharlal Nehru Krishi Vishwa Vidhyalaya Jabalpur, M.P.482004, India

*Corresponding Author Email ID: niharikas86@gmail.com

Introduction

Speed breeding is a technique in crop improvement that accelerates the breeding cycle of plants, allowing for quicker development of new crop varieties. It contributes to the development of more resilient, productive, and sustainable crop varieties by accelerating the breeding cycle and enhancing trait selection Speed breeding offers significant advantages in terms of efficiency, flexibility and adaptability in crop improvement programs. Several benefits of speed breeding are Accelerated Breeding Cycles, Rapid Response to Environmental Challenges, Increased Genetic Diversity, Efficient Trait Selection, Reduced Costs, Improvement of Underutilized Crops,Facilitation of Genomic Approaches and Adaptation to Local Conditions.

Sustaining human life in a healthy state requires adequate food and nutrition. With a projected global population of 10 billion by 2050, meeting the escalating demand for food represents a significant challenge for agriculture-based economies. Furthermore, the agriculture sector must address the complex challenges posed by climate change, including aberrant temperature fluctuations, inadequate precipitation, and prevalence of pests and diseases as well as degradation of natural resources. To ensure nutritional security for this burgeoning population, a 60% in-crease in agricultural production is required by 2050. In order to address the challenges ofclimatic variability and meet the food demands ofa burgeoning population, novel crop varieties must be developed with targeted breeding objectives for enhanced yield, superior nutritional quality, and heightened resistance to diverse stress conditions.

Conventional breeding or classical breeding has yielded numerous potential cultivars utilizing traditional techniques without the aid of advancedtools such as molecular plant breeding or genetic engineering. Nonetheless, conventional breeding remains a time-consuming process, posing a significant obstacle in crop plant breeding. Thus, the integration of modern technologies is crucial for expediting breeding programs, promoting the rapid genetic advancement of crops and achieving de- sired breeding objectives.

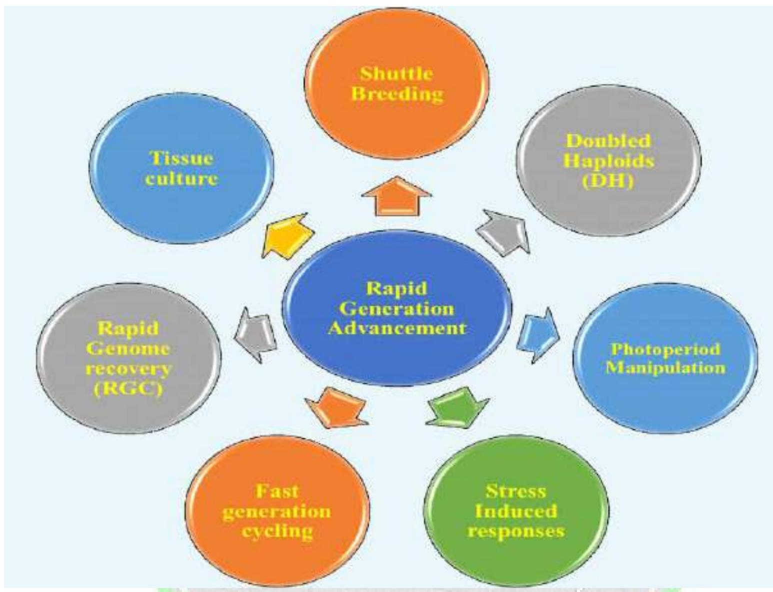


Figure 1 Current approaches utilized to decrease thebreeding cycle.

The development of new cultivars necessitates genetic fixation, followed by evaluation and assessment of multiple generations, with each generation taking a year. Typically, it takes approximately 12-14 years for a newly developed varietyto be ready for commercial cultivation by farmers. To overcome this prolonged process and meet the exponentially increasing demand for major food crops, innovative technologies such as shuttle breeding, off-season nurseries, haploid breeding, tissue culture, and manipulation of ambient temperature photoperiods have been employed to re-duce the crop life cycle and increase the number of generations per year (Figure 1). However, to meet the pressing need for rapid crop development,the concept of “Speed Breeding” has been success- fully adopted, which utilizes a suite of technologies that manipulate environmental conditions toaccelerate early flowering and seed set in differentlines.

Speed Breeding is a cutting-edge technique for rapidly advancing the breeding cycle of crops. It involves manipulating environmental conditions such as light intensity, photoperiod, and temperature to promote early flowering and seed set in different crop lines. By utilizing this approach, it is possible to achieve up to six generations per year, dramatically accelerating the breeding cycle and enabling the development of new cultivars in a shorter period of time. Speed Breeding is a promising technology that has the potential to revolutionize the field of crop improvement, facilitating the production of crops with desirable traits such as improved yield, better nutritional quality, and heightened resistance to environmental stressors.

Concept of Speed Breeding Evolution

Approximately 100 years ago, the basic principle of speed breeding began to emerge when it was discovered that plants could grow under artificial light. The term "Speed Breeding" (SB) was first used in 2003 by Queensland University, inspired by the work of NASA. The SB approach involves artificial manipulation of plant growth conditions, such as the regulation of light intensity and temperature, to accelerate the breeding cycle. Additionally, other crucial factors, including the density of plants, photoperiod, and light intensity, are manipulated to facilitate rapid generation advancement.

Essential Requirements forSpeed Breeding

The growth and development of plants in SB conditions require all essential factors under natural field conditions. However, the light, temperature, photoperiod and humidity are four main pillars of speed breeding. Regulation over the intensity of light, photoperiod and manual change in temperature enhances the plant's physiological efficiency. The principle factors of speed breeding along with their suitable range of requirements arementioned below:

Light: The intensity and quality of light are the prime requirements in SB. Manipulation in light intensity changes the rate of photosynthesis. Lightranges from 400-700 nm are pertinent for light quality which can be achieved using halogen, lamps, LEDs or Sodium vapour lamps (SVLs). Along with it the intensity of light should be about 450–500 μmol/m^2/s PPFD (Photosyn- thetic Photon Flux Density).

Photoperiod: Enhanced photope-riod is another key factor of SB. In a 24-h diurnal cycle, the 22 h of photoperiod with a night period of 2h is suggested. The 18-h of photoperiod is enough to get rapid generation cycles in crop species of oat, wheat, triticale and barley.

Temperature: Temperature, beinganother component of SB is maintainedaccording to light and dark periods. The temperature should be higher at the time of the photoperiod while it should be lowered during darkened period. Temperature is not fixed for any crop species but it is subjected to the breeding method adopted and requirement of the plant.

Humidity: A humidity level between 60-70% is optimum for most of the crops but the crops in water-stressed conditions require a lower level of humidity.

Increased generation turnover in major foodcrops under speed breeding

S.No.	Crops	No. of Generations/Year
1	Barley (*Hordeum vulgare*)	6
2	Chickpea (*Cicer arietinum*)	6
3	Groundnut (*Arachis hypogaea*)	4
4	Lentil (*Lens culinaris*)	8
5	Oat (*Avena sativa*)	7
6	Pea (*Pisum sativum*)	5
7	Pigeonpea (*Cajanus cajan*)	4
8	Rapeseed (*Brassica napus*)	5
9	Rice (*Oryza sativa*)	4-5
10	Sorghum (*Sorghum bicolor*)	4
11	Soybean (*Glycine max*)	5
12	Wheat (*Triticum aestivum*)	4-6

Generation Turnover in Crop

Increased number of generations per year of a crop is the basic principle of speed breeding. With the continuous hard work and successful efforts of the plant breeders, the number of generations per year of many crops has increased. In long-day crops such as Lentils, the number of generations per year increased up to 8 generations, 4-6 generations in Wheat, 6 generations in Barley, 7 generations in oats, and up to 5-6 generations in peas. Successful attempts for increasing number of generations per year are not only done in long-day plants but also in short-day plants such as up to 4 generations in Sorghum and Groundnut, 5 generations in soybeanand 4-5 generations in Rice (Table 1)

Speed Breeding 2.0

The techniques of speed breeding are focused on manipulating key factors such as light duration and intensity, temperature and humidity, which play crucial roles in rapid generation advancement. In addition, various other factors can also be employed to increase the number of generations per year, including (i) breaking seed dormancy through techniques such as cold treatment and vernalization,(ii) early seed harvest followed by artificial dryingand cold treatment, (iii) optimization of day lengthand light quality by adjusting the ratio of differentlight colors and durations, (iv) elevating CO2 concentration to increase the rate of photosynthesis, inducing high temperatures and water stress during key growth stages to trigger vegetative and reproductive growth, and (vi) application of plant growth regulators to enhance vegetative growth and promote early seed harvest. The application of these factors, individually and collectively, can greatly enhance breeding programs.

Methods of Speed Breeding

The implementation of SB necessitates adherence to a comprehensive protocol that outlines the procedures involved in the breeding program. This protocol provides detailed guidelines for the manipulation of light, temperature, photoperiod and humidity within a controlled environment to enhance the rate of physiological processes. Although there is no standardized SB protocol that applies to all crops, the methods employed vary across different crop species. Multiple scientists have developed distinct protocols for crops such as wheatand barley, rice, peanuts, chickpea, soybeans andlentils.

Watson *et al.* (2018) developed three different methods of speed breeding as below:

i Speed Breeding I- Controlled environ*ment chamber:* This method was developed for wheat, barley and seeds of *Brachypodium.*

- Photoperiod: 22-hour;
- Temperature 22 °C
- Dark period: 2-hour
- Temperature 17°C
- Humidity: 70%.
- Light intensity: 360–380µmol/m2/s at bench height,
- Light intensity: 490–500 µmol/m2/s at adult plant height

ii Speed Breeding II- Glasshouse speed breeding conditions: This method was developed for the seeds of chickpeas, canola barley, and wheat.

- Photoperiod: 22-hour;Temperature 17/22 °C
- Dark period: 2-hour; Temperature 17°C
- Light intensity: 440–650 µmol/m2/s at adult plant height

iii Speed Breeding III-Homemade growth room design for low-cost speed breeding:

The homemade method of SB was developed for barley, wheat and canola. It requires a completely shielded room of $3m^3$.

- Photoperiod: 12-hour; Temperature 21 °C(For first 4 weeks)
- Dark period: 12-hour; Temperature 18°C

(For first 4 weeks)

- Photoperiod: 18-hour; Temperature 21 °C
- Dark period: 06-hour; Temperature 18°C
- Light intensity: 210–260 µmol/m2/s atbench height,
- Light intensity: 340–590 µmol/m2/s at adult plant height

S. No.	Crops	Protocols
1	Barley (*Hordeum vulgare*)	Light: 22h, Temp: Day: 22°C, Night: 17°C, Light Intensity: High PAR, Early seed harvest
2	Groundnut (*Arachis hypogaea*)	Light: Continuous, Temp: Day: 28°C, Night: 17°C, Light Intensity: High PAR
3	Pearl Millet (*Pennisetum glaucum*)	Better growth was observed at 38°C than 31 °C
4	Rapeseed (*Brassica napus*)	Light: 22h, Temp: Day: 22°C, Night: 17°C, Light Intensity: High PAR, Early seed harvest
5	Rice (*Oryza sativa*)	Light:10h, Temperature: Day: 27°C, Night: 25°C Soil requirement/plant: 260 cm^3, CO2 Supplementation: 560–800ppm
6	Soybean (*Glycine max*)	Light: 14h; Temp: Day: 30°C, Night: 25°C; CO2 Supplementation: 400–600ppm:
7	Wheat (*Triticum aestivum*)	Light: 22h; Temp: 22°C, Night: 17°C; Light Intensity: High PAR, Early seed harvest

Table 2: Protocols of Speed Breeding in different crops

(Source: Hickey *et al.*, 2019)

Applications and Achievements

Speed Breeding is a valuable tool for plant breeders, as it allows for rapid generation advancement and the evaluation of physiological traits in crops. The technique can increase breeding cycles by 2-3 generations per year for photo-sensitive crops, and up to 6 generations per year for photo- in sensitive crops. Additionally, Speed Breeding is used to accelerate genomic selection methods, gene.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

CLEANLINESS AND MANAGEMENT IN JAGGERY PRODUCTION UNITS

Article ID: AG-VO4-I12-114

***Dr. Govind Yenge, Mr. Kaustubh Nakate, Dr. Vidyasagar Gedam and Dr. BapuraoGaikwad**

* All India Coordinated Research Project on Post Harvest Engineering and Technology, Regional Sugarcane and Jaggery Research Centre, Kolhapur-416005, India

*Corresponding Author Email ID: govindyenge89@gmail.com

Introduction

Sugarcane stands as a pivotal cash crop in Maharashtra, underpinning the socio-economic framework of rural communities. It plays a crucial role in generating employment and fostering regional economic growth. Maharashtra is among India's leading states in sugar and jaggery production, achieving an annual output of approximately 11.886 million tons of sugar with a commendable productivity rate of 80–85 metric tons per hectare**.** The state dedicates a substantial 1.359 million hectares of land to sugarcane cultivation, signifying its profound impact on the regional economy.

The Kolhapur district**,** renowned for its fertile soils and favorable climatic conditions, has carved a distinct identity in sugarcane production. Renowned not only for its contribution to sugar manufacturing but also for producing premium grade jaggery, Kolhapur holds an esteemed position in the agro-industrial landscape. This prominence is underscored by the Geographical Indication (GI) tag awarded to Kolhapur jaggery in 2014, a testament to its exceptional quality and cultural significance.

These achievements reflect the indispensable role of sugarcane cultivation in fortifying Maharashtra's economic foundation, while also highlighting Kolhapur's unparalleled status as a hub of excellence in sugarcane and jaggery production.

Challenges in Jaggery Production

Currently, jaggery is predominantly produced using traditional methodologies, which are fraught with numerous challenges. The lack of attention to hygienic conditions during the production process, improper storage practices and an absence of precision in processing techniques often results in declining jaggery quality. This decline manifests in unfavorable alterations with its color, texture, flavor, and firmness.

Ensuring stringent cleanliness at every stage of production can significantly enhance the quality and shelf life of jaggery. Consequently, such measures can foster consumer trust and provide a new impetus to the jaggery trade. By adhering to hygienic and meticulous production standards, producers can not only cater to the domestic market but also tap into the growing demand in international markets. Adopting improved practices will allow jaggery to evolve from a locally consumed product to a globally recognized commodity, ensuring its sustained relevance and marketability.

Cleanliness: The Foundation of Quality

The principle of cleanliness is not only a physical one but also integral to mental and professional growth. At every stage of production, from the creation of juice to the storage of jaggery, the integration of modern technology and ensuring cleanliness are imperative. A clean environment, the use of cutting-edge technology, and a stringent process are the pillars of producing high-quality jaggery.

By focusing on cleanliness and quality, a foothold can be established in global markets. To achieve this, producers must adopt new technologies and push the boundaries of traditional methods. Rigorous adherence to hygiene will not only improve the quality of jaggery but will also elevate its brand value. Recognizing that **"cleanliness is the key to progress"**, producers should aim to make jaggery more refined and sustainable. This approach will not only elevate the product but also foster long-term growth and establish jaggery as a premium commodity.

Food Safety and Standards Authority of India (FSSAI):

The Food Safety and Standards Authority of India (FSSAI) is an autonomous body under the Ministry of Health and Family Welfare, established through the Food Safety and Standards Act, 2006. It plays a crucial role in ensuring food safety by formulating high-quality standards for food products, granting licenses to food businesses, and enforcing compliance with food safety regulations. FSSAI also emphasizes public awareness through advocacy campaigns and supports research and innovation in food safety. By fostering cleanliness, hygiene, and quality in food production, FSSAI has significantly enhanced food security in India, making safe and nutritious food accessible to all citizens and contributing to public health and trust in the food sector.

Biological, Physical and Chemical Hazards in Jaggery Production:

1. Biological Hazards:

- **Lack of Cleanliness**: Inadequate hygiene during processing promotes microbial growth, increasing the risk of food borne illnesses.
- **Pathogenic Contamination**: Raw materials may harbor bacteria, fungi, or viruses, posing serious health risks to consumers.
- **Insect Infestation**: Improper storage can lead to infestations by insects or rodents, compromising product safety.
- **Workplace Hygiene**: Workers failing to maintain personal hygiene, particularlynot washing hands, can introduce diseases into the production process.
- **Water Contamination**: Using contaminated water introduces harmful microbes, endangering the product and consumers' health.

2. Physical Hazards:

- **Accidents and Injuries**: The use of heavy machinery and high-temperature equipment risks burns, injuries, or accidents.
- **Foreign Objects**: Fragments from machinery or external contaminants can inadvertently enter the product, affecting safety.
- **Equipment Malfunctions**: Machinery breakdowns can disrupt production and impact product quality, necessitating regular maintenance.
- **Excessive Heat Exposure**: High heat during processing can cause burns to workers if not managed safely.
- **Unfiltered Debris**: Raw materials may contain debris or impurities that cancontaminate the final product if not adequately filtered.

3. Chemical Hazards:

- **Chemical Residues**: Improper cleaning agents or residues from filtration chemicals may remain in the product.
- **Temperature Fluctuations**: Poor temperature control can lead to the formationof harmful compounds or scorched jaggery.
- **Harmful Additives**: Excessive use of preservatives or flavor and texture enhancers can

jeopardize consumer health.

- **Precautions to Be Taken in Jaggery Production as per FSSAI Standards:**

1. **Use of Stainless Steel Equipment**:

All equipments used in jaggery production such as utensils, sieves, juice tank, filters, evaporators and other tools should be made of stainless steel, certified with the ISI mark, ensuring they meet safety and quality standards.

2. **Regular Cleaning and Sterilization**:

Utensils and equipment must be kept clean and sterilized regularly to prevent contamination during production.

3. **Personal Hygiene**:

Workers involved in production must wash their hands thoroughly with disinfectant before handling jaggery. They should wear clean cloths including gloves, masks and hair caps to maintain hygiene standards.

4. **Use of Clean Water:**

The water used in jaggery production must be pure and fresh to maintain the products quality.

5. **Medical Check-ups for Workers**:

Routine health check-ups should be conducted for workers to ensure they are free from infectious diseases.

6. **Prohibition of Tobacco and Smoking**:

Consumption of tobacco, smoking, or spitting is strictly prohibited in and around the production area.

7. **Proper Storage**:

After production, jaggery must be stored in airtight containers to prevent moisture absorption and maintain its flavor and texture.

8. **Avoid Pesticides in Production Areas**:

Pesticides and harmful chemicals should not be used near the production and storage areas to avoid contamination.

9. **Fire and Accident Safety**:

Adequate safety measures, including fire extinguishers and emergency safety equipment must be in place to prevent accidents and ensure workers safety.

Jaggery Production Process: Current Status and Precautions at various Stages:

Process	Current Situation	Precautions
Selection of Raw Materials	Proper cleanliness is not observed during the sugarcane harvesting process. The sugarcane brought for jaggery production is not washed, resulting in the contamination of the juice with soil and other impurities. This lack of hygiene compromises the quality of the jaggery and possesses potential health risks.	The tools used for sugarcane harvesting must be kept scrupulously clean. The sugarcane should be fresh, free from any extraneous materials such as leaves and devoid of harmful substances. The cane should not be contaminated with soil, mud or other residues. For jaggery production, it is recommended to use varieties of sugarcane developed by Mahatma Phule Krishi Vidyapeeth. For ex. Co-92005, CoM-09057, Co-8014 (Mahalakshmi), Nira-86032, Co-7527 and Co-15012.
Extraction of Juice	The equipment used for sugarcane juice extraction, including crushers and grinders, is often not properly cleaned leading to the risk of bacterial contamination. The juice is collected in plastic or sometimes cement tanks, which may not meet the required hygiene standards, further increasing the chances of contamination	The machine used for juice extraction must be thoroughly cleaned and regularly washed. The storage collection tanks for the juice should be made of stainless steel (SS-304 grade) with an appropriate system for transferring the juice to the boiling vessel. The juice should be filtered through a nylon sieve or a dual-layer filtration system developed by this (AICRP on PHET & RSJRS) research center. The tank should be designed with slanted, semi-spherical or conical shapes to allow heavy impurities to settle at the bottom.
Purification of Juice	During the clarification process, if the work is done in an open area, dust, insects or other contaminants can enter the juice. The pan used for	To ensure hygienic conditions, the pan & molds should be cleaned thoroughly. If not properly cleaned, harmful microorganisms from the kettle could contaminate the jaggery. The

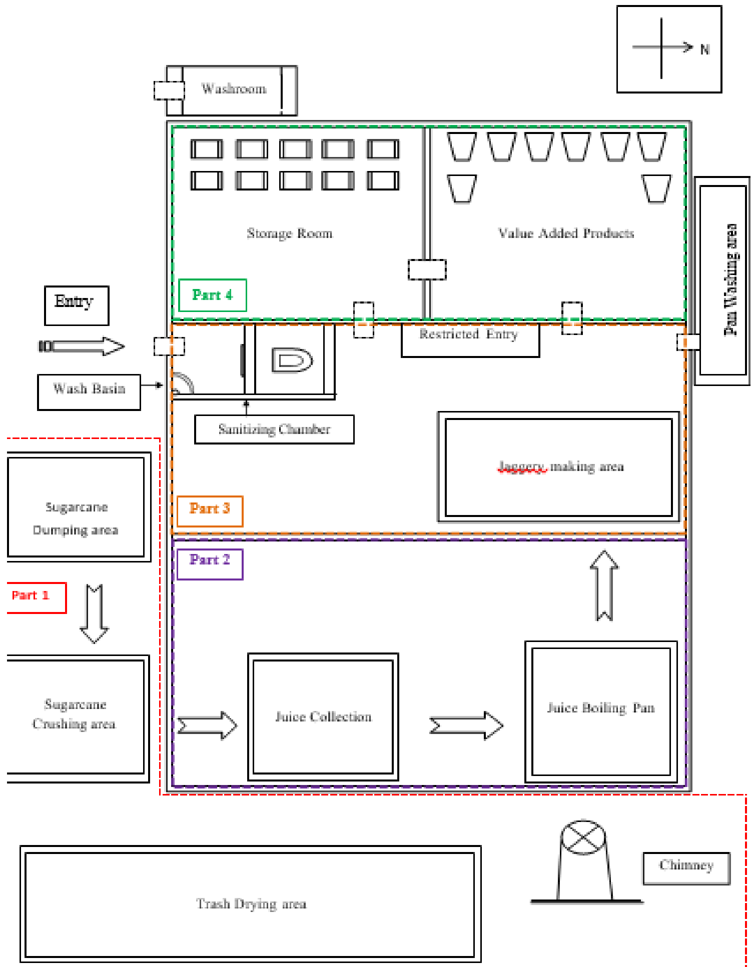
	boiling should be free from contamination and those made from metal should be avoided due to potential hygiene issues. Water used for cleaning must be clean, and there is often a noticeable lack of cleanliness around the pan.	boiling pan must be made of stainless steel (SS 304 grade) as it resists corrosion and bacterial growth, making it idealfor maintaining cleanliness. It is essential to ensure that smoke or dust generated by the burning fuel does not contaminate the juice, maintaining its purity and quality.
Evaporation	To achieve a darker yellow color, chemical additives such as Sodium hydrosulfite or Sodium dithionite or *Abelmoschus esculentus* are often used excessively. Proper quantity of chemicals is not used. This can lead to a noticeable alteration in the taste and overall quality of the jiggery.	To ensure optimal quality, use a Thermometer to monitor the juice temperature and carefully remove sediment with a ladle. Avoid using harmful chemicals. Groundnut oil can help prevent the syrup from burning.
Conditioning the Syrup	In traditional methods, there is no formal quality inspection of jaggery. Additionally, people often lack adequate information about using modern equipment.	To ensure better quality, it is important to handle the juice carefully to avoid burning during boiling. Using tools like a Brix meter or thermometer can help determine when the juice has reached the desired maturity level.
Crystallization and filling Molds	In traditional jaggery production, the process of pouring jaggery into molds involves unhygienic practices, such as using bare hands and no gloves or masks. Workers, often wearing slippers, handle the jaggery directly, risking contamination. The jaggery is left to cool in open spaces, exposing it to dust and insects.	Workers should wash their hands thoroughly; wear gloves and masks while filling molds. Ensure proper safety measures while handling hot jiggery to prevent burning. Using a mechanized system, like the one developed by the AICRP on PHET, Regional Sugarcane and Jaggery Research Station in Kolhapur, can enhance cleanliness and efficiency. Molds should be elevated slightly

		from the ground for ease and cleanliness and molds made up of stainless steel (SS 304 grade) should be used.
Storage of Jaggery	Jaggery is often stored in unhygienic conditions, with the finished product being placed directly on the ground. Inappropriate, unhygienic containers are used during packaging which leads to mold growth.	Jaggery should be stored in a clean, dry, well-ventilated and airtight location. It is crucial to use appropriate containers to avoid contamination. To prevent insect damage an electric UV light trap can be used to keep pests at bay.

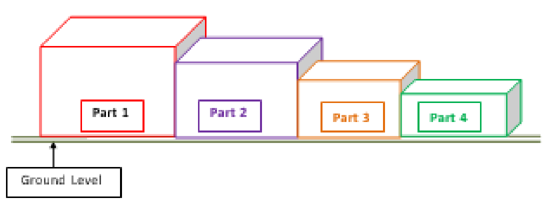
Current Scenario:

(Source: Internet)

"These visuals portray the unsanitary conditions prevalent in a jaggery production facility,which significantly compromise health and safety standards."



- **Representation layout for modern Jaggery Production Unit**



- **Elevation for the Jaggery Production Unit**

Acknowledgement

Author, grateful to the Indian Council of Agricultural Research - All India Coordinated Research Project on Post-Harvest Engineering and Technology (AICRP on PHET, ICAR-CIPHET), Ludhiana for the financial support to conduct various research on jaggery.

Volume: 04 Issue No: 12

HARVESTING HOPE: INSPIRING SUCCESS STORIES OF NATURAL FARMING IN TAMIL NADU

Article ID: AG-V04-I12-115

***M. Suganthy, P. Janaki, E. Parameswari, R. Krishnan, M. Ramasubramanian and M. Kavino**

Nammazhvar Organic Farming Research Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

*****Corresponding Author Email ID**:** suganthy@tnau.ac.in

Introduction

Natural farming has gained significant momentum among farmers in Tamil Nadu, with a growing number adopting natural and organic practices, especially in the post-COVID-19 era. This article highlights the success stories of these farmers, showcasing the variety of crops cultivated, improvements in soil health, increased yields, and reduced farming costs. These inspiring accounts underline the transformative potential of natural farming in promoting sustainable agriculture.

Coconut-Based Multi-Layer Natural Farming: The Visionary Success of Dr. Sampath Kumar

Dr. Sampath Kumar, a Ph.D. holder in Mechanical Engineering and a professor at a reputed engineering college near Coimbatore, has carved an inspiring path as a successful natural farmer and entrepreneur. Over the past 12 years, he has transformed his 10-acre certified organic farm, *Pragathi Nature Farm*, located in Jakkarpalayam village near Pollachi, into a thriving example of sustainable agriculture.

Situated in Tamil Nadu's coconut-rich Pollachi region, his farm showcases a sophisticated multi-layer cropping system centered around 45-year-old West Coast Tall coconut trees planted at 27-foot intervals as the top layer. The second layer features tree crops such as mahogany, bulbous teak, kaya, kadam, neem, and sandalwood. The third layer is filled with fruit crops, including banana, water apple, jackfruit, jamun, custard apple, and pomegranate. The fourth layer accommodates papaya and moringa, while the fifth layer utilizes available spaces for pepper, turmeric, and ginger.

Dr. Sampath Kumar has also optimized his farm's borders by planting green manure and fodder crops like *Glyricidia*, *Sesbania grandiflora*, and *Desmanthus* to support his livestock, which includes Kangeyam cows, goats, and native chickens. Additionally, trap crops such as marigold, calotropis, and castor aid in pest management while enriching soil fertility.

Innovations and sustainability practices

Implementing the four pillars of natural farming—*Beejamrit*, *Jeevamrit*, mulching, and *Whapasa*—Dr. Sampath Kumar maintains about 40 Kangeyam cows, including rescued and aged animals, in a thoughtfully designed "cow hostel." These cows provide nutrient-rich resources, such as cow dung and urine, for preparing organic manures. The farm also houses 25 goats and 75 native chickens, further diversifying its ecosystem.

Leveraging his engineering expertise, Dr. Kumar has developed and patented cost-effective solutions, including a biogas plant to meet the energy needs of farm labourers and a filtering unit for automated *Jeevamrit* production and distribution via the drip irrigation system. His innovative irrigation system ensures that nutrient-rich concoctions are supplied to crops every seven days, promoting vigorous growth.

Remarkable results

Years of dedicated natural farming have significantly improved soil health on his farm, with soil organic carbon levels rising from 0.28% in 2012 to 2.38% in 2023. This transformation has translated into impressive yields, with each coconut tree producing 250-260 nuts annually compared to 160-170 nuts on neighbouring conventional farms. All plant and animal waste generated on the farm is meticulously recycled into mulch or compost, ensuring a closed-loop system that enriches soil fertility.

Value addition and revenue generation

Dr. Sampath Kumar emphasizes value addition as a cornerstone of his success. His coconut-derived products include seedlings, ball copra, coconut oil, and cocopeat, boosting the revenue per coconut from ₹10 to ₹100. Similarly, his solar-dried bananas fetch ₹450-500 per kilogram. The farm also generates income from *Jeevamrit*, vermicompost, and saplings of fruit and timber trees.

Through his digital platform https://cuckoonaturefarms.com, Dr. Sampath Kumar markets his products, further expanding his reach. He also provides consultancy services, assisting fellow farmers with knowledge sharing and establishing automated *Jeevamrit* systems.

Key to success

Dr. Sampath kumar credits his success to adopting an integrated farming system, recycling farm waste, creating wealth from waste, adding value to farm produce, and leveraging digital platforms for marketing. His innovative approach has increased his income four to five times his investment, making him a beacon of sustainable and profitable agriculture.

His journey exemplifies how ingenuity, dedication, and respect for natural systems can create a flourishing and eco-friendly agricultural enterprise, inspiring countless others to follow suit.

Multi-layered coconut farming

Amirthakaraisal unit

Biogas unit

Value added products of Pragathi Farms

Rice Production through Natural Farming: The Inspiring Journey of Mrs. Lakshmi Devi

Mrs. Lakshmi Devi, from Ambasamudram in Tamil Nadu's Thirunelveli district, is a shining example of resilience and determination in the realm of natural farming. Once an employee of BSNL, Lakshmi Devi faced severe health challenges, including thyroid issues and a recommendation for uterine surgery due to pesticide and heavy metal residue-laden food. Determined to take control of her health, she decided to embrace organic farming, not just for herself but for a healthier future.

She took voluntary retirement and began her journey on a modest 0.5 acre plot. Despite lacking prior agricultural knowledge and facing skepticism from her neighbours, Lakshmi Devi's resolve remained unshaken. She immersed herself in learning natural farming techniques by reading books and utilizing media resources.

Her initial struggles soon bore fruit as she cultivated traditional rice varieties and grew vegetables in her backyard garden. After three years of consuming naturally grown produce from her farm, Lakshmi Devi experienced a remarkable recovery, avoiding surgery entirely.

Encouraged by her success, she expanded her farm to 7 acres, incorporating livestock and agroforestry to enhance nutrient cycling and soil health. The same neighbours who once doubted her approach began praising her thriving fields, bountiful harvests, and renewed vitality. Today, Mrs. Lakshmi Devi preserves and cultivates 100 traditional rice varieties, known for their nutritional value and immunity-boosting properties, while also supplying seeds to fellow farmers.

Understanding the importance of profitability, she ventured into value-added products like rice porridge and pudding dough, catering directly to consumers. By diversifying her rice varieties to meet customer preferences and ensuring a consistent supply, she established a sustainable and successful farming model. With the support of a paddy dehusking machine funded by the Department of Agricultural Engineering, she now supplies red and black rice as unpolished and hand-pounded varieties. This value addition has further enhanced her market appeal.

Lakshmi Devi attributes her success to nature's support, meticulous planning, self-reliance, and an unwavering focus on quality. She believes that understanding market demand, customer preferences, and the production of superior products can make success attainable for any farmer.

Her inspiring story underscores the transformative power of natural farming, proving that with determination and the right strategies, even the smallest beginnings can lead to extraordinary achievements.

Mrs. Lakshmi Devi was honoured by the Chief Minister of Tamil Nadu with a prestigious award for her remarkable dedication to cultivating traditional rice varieties through natural farming

Mrs. Lakshmi Devi: Guardian of heritage, preserving 100 traditional rice varieties for future generations

Integrated Natural Farming System: A Two-Decade Journey of Sustainability

Mrs. Nagarathinam and her husband, Dr. T. M. Manickaraj, a dedicated paediatrician, have been pioneers of natural farming for over 20 years on their 23 acre farm, *Seethavanam and Marudhavanam Natural Farms,* located in Pudhupalayam village, Thondamuthur block, Coimbatore District. Their farm, a lush tapestry of biodiversity, is a testament to the transformative power of natural farming.

Coconut, mango, and sapota are their primary crops, complemented by a variety of intercropped species, including mulberry, turmeric, coffee, cocoa, nutmeg, teak, pepper, and vegetables. Initially, the couple practiced conventional farming for 12 years, relying heavily on chemical fertilizers and pesticides. However, Dr. Manickaraj, driven by his medical insights into the health issues in children such as allergies, diarrhoea, and skin conditions linked to adulterated food, urged a shift toward organic farming.

In 2003, inspired by a seminar on organic farming and certification, Mrs. Nagarathinam spearheaded their transition to organic methods, guided by renowned agricultural expert Dr. Nammazhvar. Despite initial challenges, including managing pests in mango crops, they gradually overcame these hurdles using bio-inputs. Within three years, they noticed remarkable improvements in the taste, quality, and yield of their produce.

However, relying on purchased bio-inputs made organic farming cost-intensive. Determined to reduce costs and enhance sustainability, the couple embraced natural farming in 2008 after attending a workshop by Padma Shri Subhash Palekar. By 2017, they fully transitioned their farm to Subhash Palekar Natural Farming (SPNF) practices after undergoing advanced training in Pune.

Mrs. Nagarathinam discovered that a single *desi* cow could support the cultivation of 10 acres, drastically reducing external input costs while boosting farm productivity. Natural farming has significantly improved the biological fertility of their soil, enabling a thriving ecosystem.

Seethavanam

IFS Unit

Jeevamrit unit

To enhance profitability, they diversified their offerings by adding value to their produce. Their wide range of products includes pepper and ginger pickles, fruit jams, squash, and coconut oil, all of which have gained popularity among consumers. The installation of a drip irrigation system further optimized their operations, conserving water and facilitating the delivery of bio-fertilizers like *jeevamrit* and other liquid organic manures.

Their commitment to sustainable practices extends beyond agriculture. By adhering to Good Agricultural Practices (GAP), they contribute to environmental preservation while promoting safe and nutritious food for consumers. The couple strongly believes that natural farming is not just a method but a responsibility, enabling farmers to foster a healthier society and ensure the well-being of future generations. Mrs. Nagarathinam and Dr. Manickaraj's journey serves as an inspiring blueprint for sustainable farming, proving that dedication, innovation, and respect for nature can yield bountiful rewards for the land, its caretakers, and the communities they nourish.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

MORINGA AS A SUPERFOOD: NUTRITIONAL COMPOSITION AND THERAPEUTIC APPLICATIONS

Article ID: AG-V04-I12-116

***Shivanjali sarswat**

Division of Vegetable Science, Faculty of Horticulture and Forestry, SKUAST-Jammu-180009

*Corresponding Author Email ID: Sarswatshivanjali@gmail.com

Abstract

People are increasingly concerned with their lifestyle and health these days since socioeconomic position has changed significantly. Beyond conventional nutrients, natural goods provide a vast array of potential health advantages. One such tree with significant nutritional and therapeutic value is Moringa oleifera. In addition to other bioactive chemicals, it is abundant in macro- and micronutrients that are essential for the body's regular operation and the avoidance of several illnesses. This precious shrub belongs to family Moringaceae and is distributed in many tropical and subtropical nations. In addition to being an excellent source of protein, vitamins, β-carotene, amino acids, and other phenolics, different portions of this plant have a profile of vital minerals. A unique and abundant blend of zeatin, quercetin, β-sitosterol, caffeoylquinic acid, and kaempferol is found in the Moringa plant. This leaves, blossoms, seeds, and nearly every other component are edible and offer a wealth of medicinal benefits, including as anti-inflammatory, anti-cancer, anti-ulcer, antibacterial, and antioxidant effects.

Keywords: Moringa oleifera, Superfood, antioxidant and anti-inflammatory

Introduction

Moringa scientifically known as *Moringa oleifera* often called as “drumstick tree” horseradish tree” or “miracle tree”. With its exceptional nutritional and therapeutic qualities has become a wonderful botanical wonder. This tree, is a fast growing drought-resistant tree belonging to the family Moringaceae which is indigenous to the Indian subcontinent, grows quickly and can withstand drought. it has drawn a lot of interest due to its therapeutic and nutritional qualities. The perennial plant has been used for centuries and decades due to its therapeutic qualities and health advantages. It is well recognised for its antifungal, antidepressant, anti-inflammatory, and antiviral qualities, which help to strengthen the body's immune system and prevent cell damage. It is grown primarily for its leaves and immature seedpods. The leaves aid in protecting the liver from oxidation and toxicity by being used as vegetables and in herbal medicine. By lowering oxidative stress, raising the liver's protein content, and purifying water, Moringa oil can help return liver enzymes to normal levels.

Health Benefits

According to studies, *M. oleifera* is one of the most accessible and reliable substitutes for a healthy diet. The vital nutrients found in almost every section of the tree are used. Beta-carotene, minerals, calcium, and potassium are abundant in *M. oleifera* leaves. About 70% of dried leaves are made up of oleic acid. This qualifies them for use in the production of moisturisers. In India, "Zija" is the most well-liked beverage made from the powdered leaves. Tree bark is considered to be highly effective in treating a variety of conditions, including toothaches, ulcers, and high blood pressure. However, it has been shown that roots can help cure paralysis, helminthiasis, and toothaches. (Pareek *et al*.,2023). The high protein content of Moringa makes it a very useful supplement. It has many different health benefits, such as having 10 times more vitamins than carrots, 7 times more vitamin C than oranges, 17 times more calcium than milk, and 15 times more potassium than bananas (Rockwood *et al*., 2013).

Morphology

The tree prefers a height of 500 meters above sea level and grows quickly in loamy, well-drained sandy soils (Fuglie.,1998). The tree is typically small to medium in size, with naturally trifoliate leaves, flowers that are produced on an inflorescence that is 10 to 25 cm long (Mallenakuppe., 2019), and fruits that are typically trifoliate and called "pods" (Chaudhary.,2017). The brown seeds have a semi-permeable shell, the trunk often develops straight but occasionally poorly formed, the branches are typically haphazard, and the canopy is umbrella-shaped. Each tree may produce around 15,000–25,000 seeds year.

Health Benefits:

Anticancer and Antitumor Activity: The chemicals found in leaves that are considered to have anticancer properties are benzyl isothiocyanate, niazimicin, and glucosinolates. A bioactive substance found in Moringa leaves called "niazimicin" demonstrated possible anticancer properties (Guevara *et al*., 1999).

Antidiabetic and Healing Properties of Wounds: According to reports, moringa plays a significant role in diabetes management. It has been discovered that moringa leaves significantly lower blood glucose levels right after consumption (Mittal *et al*.,).

Antimicrobial and Anthelmintic Activities: *Moringa oleifera* leaf, flower root, and stem bark extracts exhibit anthelmintic and antibacterial qualities. Pterygospermin exhibits potent fungicidal and antibacterial properties. (Ruckmai *et al*., 1998).

Antiasthmatic Activity: *M. oleifera* seed kernels improved the treatment of patients with bronchial asthma and their concomitant respiratory functioning without causing any negative side effects (Agrawal and Mehta 2008 .

Antidiuretic and cardiac and circulating stimulant actions: Moringa tree bioactive compounds, known as alkaloids, function as cardiac stimulants that stabilise blood pressure, affect diuretic action, and lower fat and cholesterol to avoid hyperlipidaemia and lower serum triglycerides and cholesterol levels (Ara *et al*.,2008).

Analgesic Activity: The leaves, pods, roots, and other components of Moringa plants all exhibited analgesic properties. The tail immersion approach revealed the same analgesic efficacy as the alcohol extract of Moringa leaves (Sutar *et al*., 2008).

Antipyretic action: Using various extracts (ethanol, petroleum ether, ethyl acetate, etc.), the antipyretic effect of Moringa was evaluated in rats; ethanol and ethyl seed extracts had the highest activity (Hukkeri *et al.*, 2006).

Antiulcer and antispasmodic effects: Moringa trees are traditionally used to treat gastrointestinal motility disorders due to their spasmolytic action (Gilai *et al*., 1994).

Other Medical Uses. Bioactive substances with anti-inflammatory properties found in M. oleifera pod components may help to slow the progression of chronic disorders linked to inflammation (Muangoi *et al.*, 2012).

Trend in Market

People are considerably more interested in eating wholesome, nutrient-dense food these days as they are conscious of health-related concerns. For example, foods with several health advantages can either prevent or treat a number of chronic illnesses. Superfood is another name for this type of exceptional cuisine.

The markets for Moringa are anticipated to grow dramatically on a global scale in the near future. By 2025, the global market for Moringa products is predicted to grow by 9.3%, or USD

7902.9 million, according to the MRFR analysis report. Compared to the global contribution, the Asia Pacific region accounted for the highest proportion of the market for Moringa products in 2018 (35.30%).

New Zealand, China, India, and Australia are important nations that are boosting the economy. The largest producer of Moringa is Asia Pacific. Due to the traditional uses of Moringa in skincare, hair care, and wellbeing, the majority of the region's supply is eaten locally. By 2025, the North American market is anticipated to grow at a CAGR of 10.0%.

Risk (Cadman., 2020) :

- Although Moringa leaves alone can meet a pregnant woman's daily iron and calcium needs, they may also have antifertility effects in certain situations.
- While Moringa leaves support thyroid function, they may interfere with the use of any other thyroid medication.
- Moringa leaves effectively lower blood sugar, they may occasionally result in too low blood sugar levels.
- Moringa is used to lower blood pressure, but Moringa combined with blood pressure-lowering medications may cause too low blood pressure.

References

Agrawal, B., and Mehta, A. (2008). Antiasthmatic activity of *Moringa oleifera* Lam: a clinical study, *Indian Journal of Pharmacology*. 40(1), 28–31.

Ara, N., Rashid, M., and Amran, M.S. (2008). Comparison of *Moringa oleifera* leaves extract with atenolol on serum triglyceride, serum cholesterol, blood glucose, heart weight, body weight in adrenaline induced rats. *Saudi Journal of Biological Sciences*.15(2), 253–258.

Cadman, B. (2020). What makes Moringa good for you. *Medical News Today*

Chaudhary, K., and Chourasia, S. (2017). Nutraceutical properties of *Moringa oleifera*: A review. *EJPMR.* 4, 646–655.

Fuglie, L.J. (1998). Producing Food without Pesticides: Local Solutions to Crop Pest Control in West Africa. *Church World Service: Dakar, Senegal*, 1–158.

Gilani, A.H., Aftab, K., and Suria., A. (1994). Pharmacological studies on hypotensive and spasmolytic activities of pure compounds from Moringa oleifera. *Phytotherapy Research*. 8(2), 87–91.

Guevara, P., Vargas, C., and Sakurai, H. (1999). An antitumor promoter from *Moringa oleifera* Lam. *Mutation Research Genetic Toxicology and Environmental Mutagenesis*. 440(2), 81–188.

Hukkeri, V.I., Nagathan, C.V., Karadi, R.V., and Patil, B.S. (2006). Antipyretic and wound healing activities of *Moringa oleifera* Lam. in rats. *Indian Journal Pharmaceutical Sciences*. 68(1), 124–126.

M. Mittal, P. Mittal, and A. C. Agarwal. (2007). Pharmacognostical and phytochemical investigation of antidiabetic activity of *Moringa oleifera* lam leaf. *The Indian Pharmacist*. 6(59), 70–72.

Mallenakuppe, R., Homabalegowda, H., Gouri, M.D., Basavaraju, P.S., and Chandrashekharaiah, U.B. (2019). History, Taxonomy and Propagation of *Moringa oleifera*-A Review. *International Journal of Life Science*. 5, 2322–2327

Muangnoi, C., Chingsuwanrote, P., Praengamthanachoti, P., Svasti, S.,and Tuntipopipat, S. (2012). *Moringa oleifera* pod inhibits inflammatory mediator production by lipopolysaccharide stimulated RAW 264.7 murine macrophage cell lines. *Inflammation*. 35(2), 445–455.

Pareek, A., Pant, M., Gupta, M.M., Kashania, P., Ratan, Y., Jain, V., Pareek, A., and Chuturgoon, A.A. (2023). *Moringa oleifera*: An Updated Comprehensive Review of Its Pharmacological Activities, Ethnomedicinal, Phytopharmaceutical Formulation, Clinical, Phytochemical, and Toxicological Aspects. *International Journal Molecular Sci*ence. 24, 2098

Rockwood, J.L., Anderson, B. G., and Casamatta, D.A. (2013). Potential uses of *Moringa oleifera* and an examination of antibiotic efficacy conferred by M. oleifera seed and leaf extracts using crude extraction techniques available to under-served indigenous populations. *International Journal of Phytothearpy Research*. 3 (2),61–71.

Ruckmani,K., Kavimani, S., Anandan, R., and Jaykar, B. (1998). Effects of *Moringa oleifera* Lam on paracetamol-induced hepatoxicity. *Indian Journal of Pharmaceutical Science*. 60(1), 33–35.

Sutar, N.G., Bonde, C.G., Patil, V,V., Narkhede, S.B., Patil, A.P., and Kakade, R.T. (2008). Analgesic activity of seeds of *Moringa oleifera* Lam. *International Journal of Green Pharmacy*. 2(2), 108–110.

Volume: 04 Issue No: 12

MICROGREENS: THE PERFECT SUPERFOOD

Article ID: AG-V04-I12-117

Mohamed Ansari Raja[1] and Parvin Banu[2]

[1] Assistant Professor, JSA College of Agriculture and Technology, Cuddalore – 606108

[2] Ph.D scholar, Tamil Nadu Agricultural Chemistry, Coimbatore – 641003, India

*Corresponding Author Email ID: ansariraja95@gmail.com

Abstract

A key force behind innovation in the food sector, which aims to satisfy consumers' growing demands and expectations for healthy foods, is the creation of innovative and functional foods. In recent years, the high-density nutrients and bioactive or secondary metabolite content of microgreens have made them appealing as functional foods. Young, leafy greens are prized for their flavor, color, and crunchiness. These microgreens are rich in antioxidants, vitamins, and minerals, and they are good for human health. On examination, microgreens and mature greens, microgreens were the best suppliers of water-soluble vitamins and zinc, which has been suggested to boost the body's immunity against the COVID-19 threat. This paper summarizes current research on microgreens, addressing knowledge gaps and obstacles regarding their nutritional value and health benefits. It advances knowledge of microgreen effects on human nutrition and health and provides insightful information for further research.

Keywords: Microgreens, Nutritious value, Health benefits

Introduction

In the past ten years, people has become more interested in eating fresh, nutritious, and useful foods like sprouted seeds and microgreens, particularly during and after the COVID-19 epidemic. Along with providing beneficial nutritional contents, they also satisfy consumers' need for taste and novelty. In an effort to strengthen their immunity, people are becoming more concerned about the environment and their health at the same time. Thus, it is unquestionably the ideal moment to present the most remarkable and developing crop in recent time:

***The Microgreens*!!**

What are Microgreens?

Microgreens are smart food products of the new generation that are becoming more and more popular over time. When microgreens initially appeared in Californian eateries in the 1980s, they were widely recognized. They are known by a variety of names, including micro herbs and vegetable confetti, these tasty greens add a wonderful splash of color to a variety of savory dishes. Despite their small size, they are up to nine times more protein-rich and often contain more nutrients than mature vegetable greens (Teng *et. al.*, 2023)

Microgreens are ideal for those who live in urban areas or have little space. No large amount of space is required to grow them, such as indoors/ balconies/ utility spaces/ corner of a room/ basements etc. Microgreens are a new type of edible vegetable that is picked before the initial leaves fully mature but before the leaves really appear. The Word "microgreen" is used in marketing to distinguish these plants from sprouts and leafy greens. There are roughly 25 different kinds of microgreens that are grown for commercial purposes worldwide. Microgreens, or young vegetable greens, are grown to a height of 2.5–7.5 cm, or 1-3 inches. They have a high nutritious content, a fragrant flavor, and come in a variety of colors and textures. Microgreens, often known as baby plants, are in the middle of a sprout and a baby green. They are not, however, to be confused with sprouts, which are leafless. After germination, when the first true leaves appear, microgreens are harvested 7–21 days later. Sprouts, on the other hand, grow in a much shorter period of 2–7 days. The stems and leaves of microgreens are considered edible, therefore they are more like baby greens. Compared to baby greens, they are much smaller, yet they can be sold before being harvested.

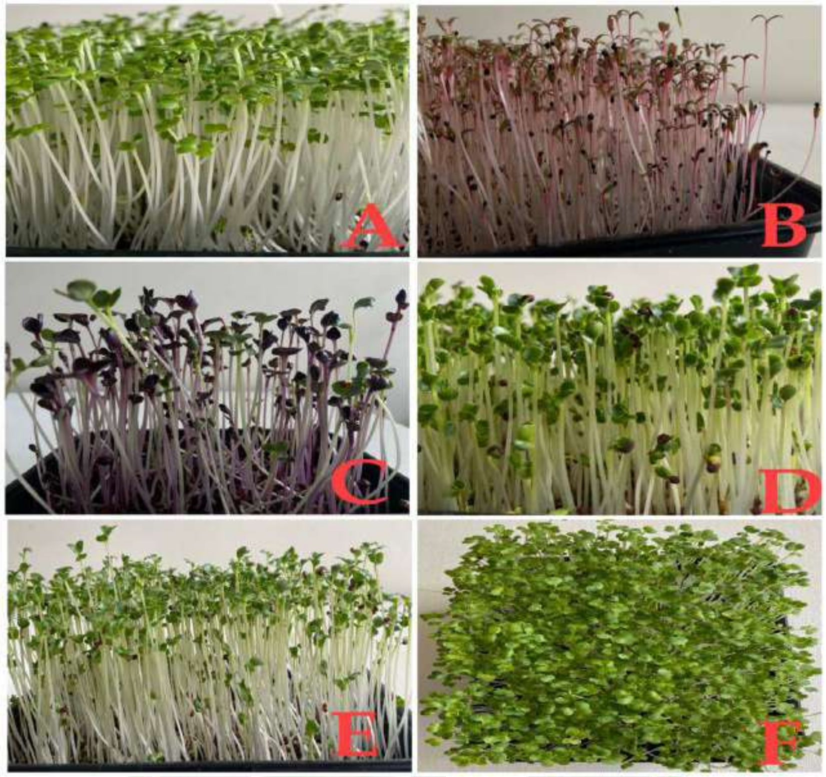
Nutritional composition of microgreens

Microgreens are more abundant in a number of micronutrients, especially minerals and vitamins. Compared to their mature counterparts, microgreens have a higher nutritional value. Vitamins A, C, E, K, enzymes, and carotenoid content vary depending on the type of microgreen, the growing medium, the temperature and amount of sunlight, and the harvesting period. Microgreens with bright colors are more nutrient-dense than those with lighter colors. When compared to sprouts, microgreens are higher in a-carotene, β-carotene, violaxanthin, lutein, and neoxanthin. They contain more zinc, iron, and protein than sprouts. It's intriguing to learn that microgreens have very low levels of antinutritional components including nitrate (NO_3^-) and nitrite (NO_2^-).

Varieties of microgreens

Since culinary trends have a significant impact on microgreens' availability and consumption, the makers' ability to discuss species selection with chefs and the customers' ability to adjust to their specific taste characteristics are key factors. Microgreens may be distributed as fresh cut items, but they can also be grown on medium for end consumers to harvest. The most utilized species include those belonging to the groups Cucurbitaceae, Amarillydaceae, Amaranthaceae, Apiaceae, Brassicaceae, and Asteraceae.

A) Asteraceae family: Lettuce, endive, chicory and radicchio
B) Amaranthaceae family: Amaranth, quinoa swiss chard, beet and spinach
C) Brassicaceae family: Cauliflower, broccoli, cabbage, watercress, radish and arugula
D) Cucurbitaceae family: Melon, cucumber and squash
E) Amaryllidaceae family: Garlic, onion, leek
F) Apiaceae family: Dill, carrot, fennel and celery



Health benefits of microgreens

Microgreens' abundance of nutrients (vitamins, minerals, fiber, and antioxidants) provides a number of health benefits. They have 4 to 40 times as much nutrients as their more mature counterparts. In addition to having a higher concentration of vitamins E, K, C, lutein, and beta carotenes, they also have a wider variety of polyphenols.

- ✓ Vitamin E benefits the skin and has cardioprotective and antioxidant properties.
- ✓ Vitamin C promotes the intestinal absorption of iron and strengthens our immune systems.
- ✓ Beta carotenes are beneficial to the immune system and aid in bone and cell development.
- ✓ Polyphenols reduce the body's risk of heart disease, cancer, and Alzheimer's disease by preventing the buildup of free radicals.

Chronic diseases like diabetes, obesity, and chronic inflammatory disorders are also prevented by microgreens. They support blood glucose regulation, tissue healing, and body weight regulation. They support the body's detoxification process.

Why are microgreens called “superfoods” ?

"Superfoods" are foods that maximize nutritional value while consuming the fewest feasible calories. Adding microgreens to our regular diet may increase their health advantages because they are rich in nutrients. The fact that microgreens offer greater nutritional concentrations than their mature counterparts lends weight to this. They are rich in antioxidants, vitamins, and minerals. Consequently, they can be considered to be superfoods. For example, USDA National Nutrient Database for Standard Reference study found that red cabbage microgreens contained six times as much vitamin C as the mature red cabbage. The red cabbage microgreens also contained 40 times as much vitamin E as their mature variant.

Benefits of growing microgreens at home for your kids

- ✓ The easiest, most amazing, and most creative approach to get your kids interested in gardening while removing them from the world of electronic devices is to grow microgreens. It promotes the growth and expression of their creative abilities, and kids will find the entire process of a little seed becoming a beautiful plant to be fascinating.
- ✓ Growing microgreens at home may be a simple, entertaining, and interesting activity for children. Among other new phrases, they will learn about sprouts, microgreens, seeding, germination, watering, and harvesting.
- ✓ They will want to eat the microgreens that they have grown themselves since they will give salads, sandwiches, omelets, pastas, pizzas, garnishes, spices, and other dishes a range of amazing flavors, vibrant colors, and exquisite textures.

Conclusion

Microgreens are categorized as a special type of functional food that contains a variety of nutrients that assist people all over the world live longer and be healthy. They are a popular addition to food because they are inexpensive and simple to grow at home. Microgreens are known for offering consumers a unique and enlightening culinary experience because of their high nutritional content, which includes potassium, iron, and zinc, as well as their pleasing appearance. Overall, microgreen farming has taken the lead in both rural and urban agricultural production. Microgreens have the capacity to serve as a powerful source of nutrients.

Reference

Teng, Z., Luo, Y., Pearlstein, D. J., Wheeler, R. M., Johnson, C. M., Wang, Q and Fonseca, J. M. (2023). Microgreens for home, commercial, and space farming: a comprehensive update of the most recent developments. *Annual Review of Food Science and Technology*, *14*(1), 539-562.

Volume: 04 Issue No: 12

IMPACT OF MICROPLASTICS ON SEED GERMINATION

Article ID: AG-V04-I12-118

Pravina K[1], Sujatha K[2*] and Alex Albert V[3]

[1]Ph.D Scholar, Department of Seed Science and Technology,

[2]Professor & Head, Department of Seed Science and Technology,

[3]Associate Professor, Department of Seed Science and Technology,

Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, India

*Corresponding Author Email ID**:** sujathakseed@tnau.ac.in

Introduction

Microplastics (MPs) are plastic particles with a diameter less than 5 mm are classified as primary or secondary microplastics based on their formation (Nel and Froneman, 2015). The primary MPs are small plastic debris. In general, primary MPs exist in cosmetics, textiles, scrubbing agents, and toiletries (Boucher and Friot, 2017). Secondary MPs are the most common source of pollution, formed when the fragmentation of larger plastic particles is fragmented by natural forces such as photo degradation, bio degradation, thermo oxidative degradation, mechanical degradation, and physical stress (Andrady, 2011). They mainly arise from waste incineration and landfills (Dris *et al*., 2016). Microplastics in soil can influence germination velocity, germination synchrony, and water retention. For instance, certain shapes, like fibers and films, slow germination velocity by up to 20%, while others, like fragments and foams, may not have such effects. Additionally, they can increase synchrony, potentially due to changes in soil-water dynamics. Microplastics (MPs) can negatively affect seed germination through a combination of physical, chemical, and biological mechanisms. Many researchers have been investigated the impact of MPs on seed germination and seedling growth and reported different adverse effects emphasizing the need for more studies to understand the effects on crop growth (Bosker *et al*., 2019; Jiang *et al*., 2019).

Physical Blockage of Soil Pore

Microplastics especially smaller particles, can clog soil pores, leading to reduced soil permeability and disrupted water and air flow. This impacts the ability of seeds to absorb water (imbibition) and oxygen both critical for germination.

Mechanism: When microplastics accumulate in soil, they physically obstruct the movement of air and water, crucial for seed imbibition and oxygen exchange. Seeds depend on moisture to initiate metabolic processes without sufficient water or oxygen, germination can be prevented. Reduced water retention and poor soil aeration and prevent germination rates, leading to failed germination **(Liu *et al*., 2020)**.

Chemical Contamination

Microplastics can adsorb various toxic chemicals such as heavy metals, pesticides, and persistent organic pollutants (POPs) from the environment. These chemicals are then released into the soil, potentially harming seeds.

Mechanism:

MPs act as vectors for toxic substances, which may leach into the surrounding environment when the particles degrade. These contaminants can affect seed germination by interfering with enzymatic activity, nutrient uptake, and growth regulation. Toxic chemicals can disrupt seed metabolic pathways, affect plant hormone signaling, or even directly damage seed DNA, all of which preventing the germination and early growth **(De Souza Machado *et al*., 2018)**.

Disruption of Soil Microbial Communities

MPs can disrupt the microbial communities in the soil, which play a key role in nutrient cycling and supporting plant health. This can reduce the nutrient availability for seeds, affecting their ability to germinate properly.

Mechanism:

Microplastics alter the composition and diversity of soil microbes. Many plant species rely on beneficial soil microbes for nutrient uptake and symbiotic relationships (e.g., nitrogen fixation, mycorrhizal fungi). Microplastic pollution can reduce microbial diversity, impairing these interactions and making the soil less fertile.Reduced microbial activity and nutrient cycling leads to a less favorable environment for seed germination, affecting seedling growth and establishment **(Tufenkji 2020)**.

Alteration of Soil Physical Properties

MPs can alter the structure and texture of the soil, affecting its density, texture, and water-holding capacity. These changes can create unfavorable conditions for seed germination and early plant development.

Mechanism: Microplastics in soil can make it more compact, altering the soil's porosity, bulk density and structure. This affects root penetrate into the soil and the water is drained or retained. Changes in soil texture can prevent seeds from establishing proper root systems, reduce water availability, and delay the nutrient absorption**(Rillig *et al*., 2017)**.

Leaching of Additives from Microplastics

Plastics often contain chemical additives such as stabilizers, plasticizers, and flame retardants, which can leach out over time into the soil. These additives can have toxic effects on plant growth and germination.

Mechanism: The leaching of chemical additives from microplastics into the surrounding soil can interupt the plant growth by disturbing with plant hormones (e.g., auxins) or causing toxicity. Seed germination may be impaired by the toxic effects of these chemicals, as they can alter growth processes or inhibit root and shoot development **(Prata *et al*., 2020)**. In addition, MPs also carry a fugal and pathogens at high diversity. Due to leaching of toxic additives, it give more challenges to the soil environment (Gkoutselis *et al.*, 2021).

Direct Physical Interaction with Seeds

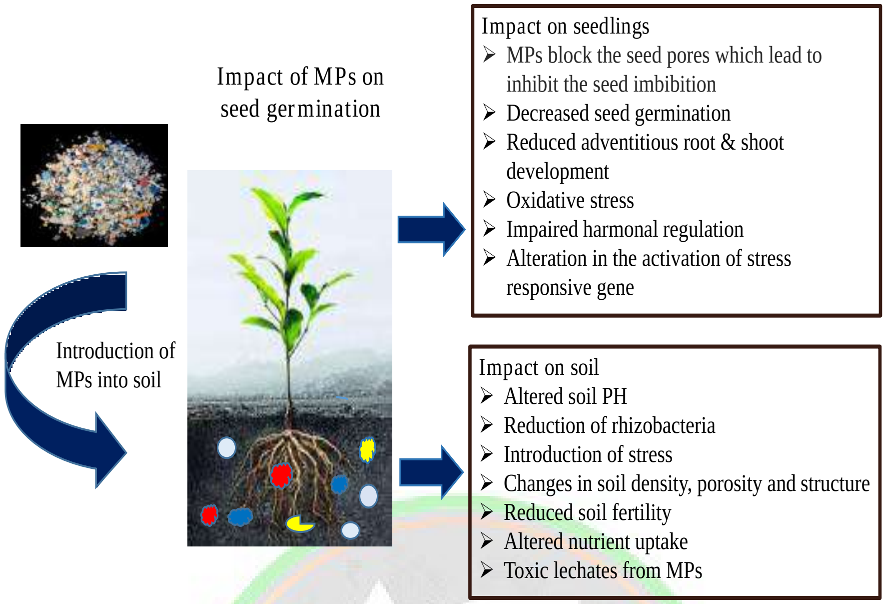
Microplastics can physically interact with seeds, either through direct contact with the seed coat or by forming a physical barrier in the soil that obstructs seed expansion.

Mechanism:

Microplastics can form a physical barrier around seeds, preventing them from absorbing water or expanding. Additionally, some types of microplastics may damage the seed coat, reducing the seed’s ability to imbibe water and begin the germination process.Physical interference with the seed's natural expansion process during imbibition can prevent the seed from initiating germination, leading to reduced germination rates or failure to germinate **(Zhang e*t al*., 2020)**.

Oxidative Stress and Cellular Damage

MPs can increase oxidative stress in plants by generating reactive oxygen species (ROS), leading to damage of cell membranes, proteins, and DNA, ultimately reducing seedling viability.



Case Studies

Polyethylene microplastics reduced the germination rate of rice seeds and altered seedling growth parameters and also found that microplastics negatively affected soil microbial communities, which play a vital role in nutrient cycling and plant development(Qi *et al.*,2018). **Zhou *et al.*, (2020)** assessed the impact of polyethylene microplastics on radish and lettuce. They found that microplastic contamination significantly reduced seed germination rates and seedling growth, particularly when higher concentrations of MPs were applied. This attributed to both physical barriers to water absorption and the leaching of toxic chemicals from the plastics. **Zhao *et al.*, (2021)studied** the effects of microplastic contamination on wheat and maize. Confirmed the reduced germination rates and poor root and shoot development, attributed to changes in soil structure and potential chemical leaching from microplastics. **Sharma & Chatterjee (2021)** noted that smaller microplastic particles caused more severe impacts significantly in spinach and radish compared to larger particles.

Beyene *et al.*, (2020) found that microplastic contamination delay the germination and inhibit the root growth in tomato and lettuce and also pointed to potential chemical toxicity due to the adsorption of harmful substances onto microplastics. Shi *et al.*, (2022) reported that seed germination was inhibited with a polypropylene (PP) concentration of 500 mg/L or less in tomato hydroponics system and adversely affected the antioxidant enzymes. Similar findings were reported by Colzi *et al.*, (2022) root and shoot growth of *Cucurbita pepo L.* was inhibited in soil treated with PP. According to Pignattelli *et al.*, (2020) PP inhibited the seed germination of garden cress by 14.3%. **Beyene *et al*., (2021)** found that microplastic particles reduced seed germination rates in apple and pear when microplastics were incorporated into the soil at high concentrations. **Jiang *et al.*, (2021) observed** that microplastics negatively affected seed germination rates and early plant growth in tomato and cucumber. Fauzia Mahanaz Shorobi *et al.*, (2023)foundthat polyethylene MPs negatively affect the germination rate and growth of black gram, due to changes in soil structure and moisture dynamics. MPs can also introduce oxidative stress and disrupt hormonal regulation, further complicating seed germination and early seedling development. This stress may lead to delayed germination.

Conclusion

Microplastics in soil can significantly impact seed germination through physical, chemical, and biological disruptions. They alter soil structure, impede water availability, and release harmful chemicals, such as pollutants and additives, which can inhibit germination. Furthermore, they disrupt soil microbial communities essential for nutrient cycling and plant health. Overall, microplastics pose a serious threat to plant development and agricultural sustainability, underscoring the urgent need to address their presence in terrestrial ecosystems. Their widespread presence in soils requires urgent mitigation strategies, including reducing plastic pollution, adopting eco-friendly agricultural practices, and further research is needed to understand long term impacts.

Volume: 04 Issue No: 12

SILICON – A BENEFICIAL ELEMENT

Article ID: AG-V04-I12-119

K.Coumaravel*
Department of Soil Science and Agrl. Chemistry,
P.J.N. College of Agriculture and Research Institute, Karaikal-609 603, India
*Corresponding Author Email ID: coumar2007@gmail.com

Introduction

Essential elements are vital for completing the life cycle of an organism. Among the 118 elements known on Earth, 17 are recognized as essential for all plants. These elements are categorized into macronutrients and micronutrients. Macronutrients include carbon (C), hydrogen (H), oxygen (O), calcium (Ca), potassium (K), magnesium (Mg), nitrogen (N), sulfur (S), and phosphorus (P). Of these, C, H, and O constitute about 95% of a plant's dry matter, while the others are generally present at concentrations exceeding 1000 mg per kg of dry weight. Micronutrients, or trace elements, include chlorine (Cl), boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn), typically found in concentrations below 100 mg per kg of dry weight. Since these are required in minimal amounts, it is possible that more micronutrients may be discovered in the future.

Beneficial elements, on the other hand, are minerals that enhance plant growth and offer advantages even in trace amounts. While they are not universally essential for all plants, they can support growth and may be critical for specific plant groups. The five most extensively studied beneficial elements are aluminum (Al), cobalt (Co), sodium (Na), selenium (Se), and silicon (Si).

Silicon

The term "silicon" originates from the Latin word *silix*, meaning "flint." In contemporary English, "silicon" refers to the chemical element, while "silica" denotes a compound where each silicon atom is bonded to two oxygen atoms (SiO_2, silicon dioxide). Silicon is a predominant component of the Earth's crust, primarily occurring as silicate minerals, secondary aluminosilicates, and various forms of silicon dioxide. However, the presence of silicon in soil does not guarantee sufficient soluble silicon for plant absorption.

Silicon (Si), the second most abundant element in the Earth's crust, is predominantly found as silicon dioxide (SiO_2), associated with numerous Si-containing minerals in crystalline, semi-crystalline, and amorphous forms (Sommer et al., 2006). While silicon itself is entirely black and opaque, silica, its oxygen-bound form, appears as a white or colourless solid that is hard, transparent, and capable of transmitting light. Often described as a versatile or quasi-element, silicon in the Earth's crust is readily absorbed by plants and transported to aerial tissues via transpiration. Silicon is recognized for its eco-friendly properties and its vital role in helping plants manage biotic and abiotic stresses. Research indicates that using silicon derived from natural silicates can alleviate the adverse effects of environmental stressors on plants while enhancing the efficiency of essential nutrients like nitrogen and phosphorus in soil and fertilizers.

Plants are classified into two groups based on their silicon uptake: silicon accumulators, which have silicon constituting more than 1% of their dry weight, and silicon non-accumulators, where silicon content is below 1% of the dry weight. Significantly, seven of the world's ten most important crops are silicon accumulators, emphasizing the need to understand silicon's functions and the mechanisms behind its uptake and movement within plants.

Table 1. Classification of different plant species according to Si accumulation

Accumulators **> 1.5 % Si** **(Frantz *et al.*, 2011)**	**Intermediate** **1.5 – 0.5 % Si** **(Pennington, 1991)**	**Non-Accumulator** **< 0.5 % Si** **(Frantz *et al.*, 2011)**
Rice	Pumpkins	Tomato
Ferns	Cucumber	Pansy
Wheat	Marigold	Snapdragon
Spinach	Chrysanthemum	Geranium
Mosses	Soyabean	Sunflower
Sugarcane	Zinnia	Gerbera
Conifers	Rose	Petunia
Horsetail	Squash	Begonia
Lentils	New Guinea Impatiens	Grapes

Silicon (Si) is a typical beneficial element. The positive effects of Si have been observed in some of the plant species such as rice, wheat, and barley, but not in all plant species. Furthermore, the beneficial effects of Si are usually expressed more clearly under stressed conditions. Since plants are always exposed to various stresses during growth, Si certainly plays an important role in alleviating stresses, ultimately resulting in increased productivity. Since 1955, Si fertilizers have been applied to paddy soils in Japan resulting in a significant increase in rice production. Various Si fertilizers are now widely applied in other countries such as Korea, China, and the USA.

Importance of Silicon for Crops

Silicon plays a key role in reinforcing plant tissues and structures. Once absorbed by the roots, it is deposited in cell walls, creating a framework that enhances rigidity and support.

- This reinforcement makes plants more resilient, enabling them to endure strong winds, heavy rainfall, and physical damage.
- Silicon boosts the plant's immune system by triggering the production of defence compounds, which help protect against pests and diseases, increasing resistance to pathogens and infestations.

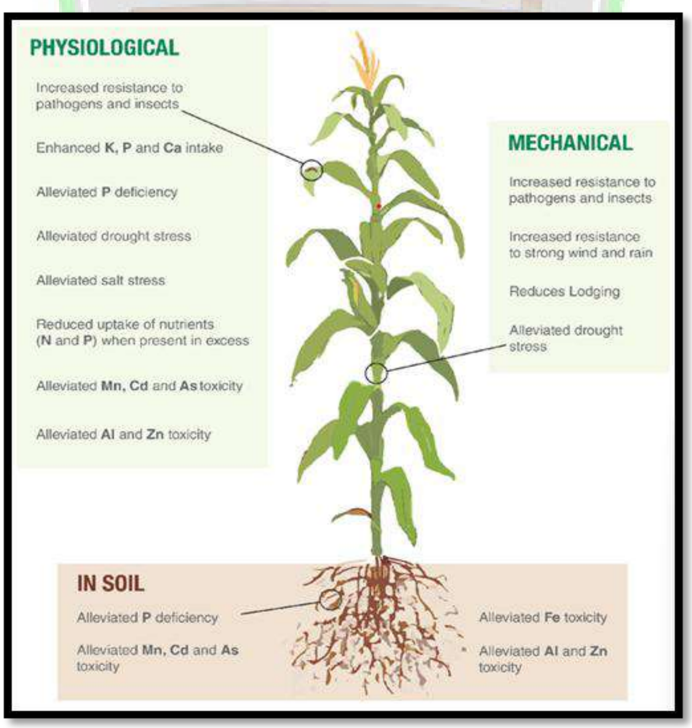


Fig. 1. Schematic representation of benefits of silica on soil and plant system

- It enhances plant tolerance to various abiotic stresses, such as drought, high temperatures, and salinity.
- By regulating water uptake, silicon improves the plant's ability to cope with water shortages and maintain adequate hydration.
- Additionally, silicon supports the uptake and efficient use of essential nutrients like calcium, potassium, and phosphorus, maximizing their availability and effectiveness within the plant.

Role of Silicon in Soil

Silica (silicon dioxide, SiO_2) plays a multifaceted role in soil, significantly influencing plant health, soil structure, and the overall soil ecosystem.

Promoting Soil Aggregation

Silica helps in binding soil particles together to form larger aggregates, they also interact with organic matter present in the soil and aids in the formation of larger and stable aggregates, making the soil well- structured with good porosity and stability. Better plant growth is encouraged by this interaction, which improves the soils' capacity to hold onto moisture and nutrients. Silicon also helps to lessen soil erosion because it increases aggregate stability.

Reducing Soil Compaction

By promoting aggregation, silica increases the soil porosity which reduces the soil compaction. Better porosity results in better root development allowing it to explore a large volume of soil for nutrients and water

Enhancing Water Infiltration and Retention

Well-aggregated soils have better infiltration rates, meaning water can enter the soil more easily during rainfall or irrigation events. This reduces surface runoff and soil erosion, making it available to plants for a longer duration, especially in sandy soils that typically have poor water-holding capacity.

Facilitating Microbial Activity

Silica enhances soil microbial activity by improving soil structure, aeration, and water retention, creating a conducive environment for microbes. It reduces plant stress caused by drought, salinity, and toxins, leading to healthier plants that release more root exudates to support microbial growth. Additionally, silica influences nutrient availability, promoting microbial processes like nitrogen fixation and organic matter decomposition, while also suppressing harmful pathogens to allow beneficial microbes to thrive. By buffering soil pH and fostering nutrient cycling, silica creates a balanced and dynamic microbial ecosystem.

Improving Nutrient content in Soil

Silica improves soil nutrient content by enhancing nutrient availability and cycling. It facilitates the release of essential nutrients like phosphorus and potassium from soil minerals by altering their chemical forms, making them more accessible to plants. Silica also supports beneficial microbial activity, which accelerates the decomposition of organic matter and the mineralization of nutrients. Additionally, it enhances soil structure, improving water retention and root growth, which further aids in nutrient uptake. By mitigating heavy metal toxicity and buffering soil pH, silica ensures a more balanced nutrient profile in the soil.

Effect of silica on plant system

- Increase resistance to pathogen and insect
- Enhances N, K, P, & Ca uptake
- Alleviates P deficiency
- Alleviates drought stress
- Alleviates Mn, Cd, Al, Zn &As toxicity
- Reduce lodging
- Resistance to strong wind and rain

Nutrient Regulation

Mali and Aert (2008) demonstrated that silicon positively influences potassium (K) uptake in both soil and hydroponic systems, even when silicon concentrations in the soil are low. They also observed that increasing the application of sodium metasilicate enhances the absorption of nitrogen (N) and calcium (Ca) in wheat, while promoting nodulation and nitrogen fixation in cowpea. Furthermore, the excessive drooping of rice leaves caused by overapplication of nitrogen can be mitigated through the inclusion of silicon in the nutrient solution. Earlier studies highlighted silicon's role in improving phosphorus availability in soil. Findings revealed that silicon treatments increased barley yields even under limited phosphorus fertilization, as it enhanced the accessibility of soil phosphorus to plants.

Conclusion

The article "silicon- a beneficial element" highlighted its pivotal contributions to plant health and soil nutrition. It fortifies plant structural integrity, enhances resistance to biotic and abiotic stresses, and improves crop yield and quality by strengthening cell walls and mitigating the impacts of drought, salinity, and temperature extremes. Integrating silicon into farming practices offers a promising approach to boosting plant resilience, improving soil health, and addressing climate change challenges, making it a critical component for achieving global food security.

Volume: 04 Issue No: 12

UNRAVELLING THE MECHANISM OF SEED AGEING: INSIGHTS INTO DETERIORATION

Article ID: AG-VO4-I12-120

R. Elamparithi[1], K. Sujatha[2*], V. Alex Albert[3]

[1.] Ph.D Scholar, Department of Seed Science and Technology,

[2.] Professor and Head, Department of Seed Science and Technology,

[3.] Associate professor, Department of Seed Science and Technology,

Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, India

*Corresponding Author Email ID: sujathakseed@tnau.ac.in

Abstract

Seed ageing is a natural, inevitable process that results in the gradual loss of seed viability and vigor over time, impacting germination, seedling growth, and overall plant productivity. The underlying mechanisms of seed ageing are complex, involving a series of physiological, biochemical, and molecular changes. Reactive oxygen species (ROS) accumulation is a key driver, causing oxidative damage to cellular components such as lipids, proteins, and nucleic acids. Lipid peroxidation of membrane phospholipids leads to loss of membrane integrity, while protein carbonylation disrupts enzyme activity and structural proteins. DNA damage, including strand breaks and base modifications, impairs genetic stability, further exacerbating the decline in seed quality. Enzymatic antioxidant systems (like superoxide dismutase, catalase, and peroxidases) and non-enzymatic antioxidants (like ascorbate and glutathione) play a protective role but decline during ageing. Metabolomic shifts, including the accumulation of stress-related metabolites, also signal the onset of seed deterioration.

Keywords: Seed ageing, reactive oxygen species (ROS), oxidative damage, lipid peroxidation, membrane integrity.

Introduction

Seeds is the fundamental units of plant reproduction, play a pivotal role in sustaining agricultural ecosystems and global food security. However, the inherent biological process of seed ageing poses a significant challenge to the longevity and viability of these essential propagules. Seed ageing is a multifaceted phenomenon influenced by various physiological, biochemical, and environmental factors. Understanding the mechanisms underlying seed ageing is crucial for optimizing seed storage, enhancing crop yield, and preserving biodiversity.

Deterioration

During storage, seed moisture content and temperature are responsible for seed deterioration, many physiological and biochemical changes occur in seeds during seed ageing. Deteriorative changes enhance when seed exposure to external challenges. It is an undesirable attribute of agriculture. Annual losses due to deterioration can be as much as 25% of the harvested crop. It is one of the basic reasons for low productivity (Shelar *et al*, 2008). The process has been described as cumulative, irreversible, degenerative and inexorable process (Kapoor *et al.*, 2011). Many physiological and biochemical changes occur in seeds during seed ageing. The physiological changes occur in deteriorated seed is loss of seed vigor in many species.

Changes in ultra structural organelles

Viability loss results in irreversible chemical and structural changes to cellular constituents. Structural changes associated with oxidation are reduced membrane fluidity, altered folding of DNA, lost elasticity of proteins and increased brittleness of the cellular matrix. Molecules oxidation leads to either smaller molecules with reactive carbonyl or nitrogen groups that easily diffuse through cells, or adducts between carbohydrates, proteins and nucleic acids that cause intermolecular cross-linking and further degrade into advanced glycation end-products.

Alterations of membrane systems, such as the tonoplast, plasmalemma and endoplasmic reticulum, result in diminishing of normal cell function and energy production. Membrane deterioration and loss of permeability occur at an early stage of deterioration.

As a result, seed cells are not capable to hold their normal physical condition and function. Causes of membrane disruption are hydrolysis of phospholipids by phospholipase and phospholipids auto-oxidation leads to enhanced free fatty acid level and free radicals' productivity (Ghassemi-Golezani *et al*., 2010).

Chromosome Aberrations

One of the changes linked with seed ageing is aberration of chromosomes, sometimes pertained to as mutagenic effect. Some of the chromosome alterations in seeds comprises fragmentation, bridges, fusion, ring formation of chromosomes and variations in nuclear size.

Changes in Mitochondria

Mitochondria become permanently swollen and lose their natural swelling contracting ability, become pigmented and fragmented (Murthy *et al*., 2003). Two aspects of mitochondrial deterioration are increase in ATPase and decline in oxidative phosphorylation ability. Aged seeds possess a lower capacity than control seeds for the electron transport chain. Ageing directly reduces the efficiency of electron transport chains, thereby reducing ATP production, so aged seeds cannot provide sufficient ATP for germination. Upon stress exposure in mitochondria, an energy deficit signal occurs, which leads to changes in organellar and nuclear gene expression.

Inability of ribosomes to dissociate

Dissociation of polyribosomes before attachment of preformed mRNA leads to protein synthesis during seed germination. In deteriorated seeds ribosomes fail to dissociate due to this protein synthesis is retarded (Walters, 1998).

Changes in cellular ultrastructural characteristics in elm seeds during Controlled Deterioration Test (CDT). (a) Summary of changes in typical cellular ultrastructural characteristics during CDT. (b) Quantification of various cell organelle ultrastructural abnormalities in the cotyledon during CDT. The percentage abnormality was calculated based on 100 cells per treatment. (c) Transmission electron microscopy images of mitochondria from cotyledons showing various states of mitochondrial morphology. Asterisks indicate double membranes, C, rudimentary cristae. Scale bars = 3 μm (main images) and 200 nm (insets).

Changes in enzyme activity

The enzymes play an important role in the progress of seed deterioration and changes in their activity can be an indication of quality loss (Copeland and McDonald, 1995). As ageing progressed germination also decreased and enzyme activity also decreased which showed significant deterioration in both accelerated as well as in natural aged seed lot.

To minimize the damaging effects of ROS, antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), and ascorbate peroxidase (APX) scavenge ROS. The amount of ROS is linked to the rate of their production and the capacity of the antioxidant system. Overexpression of genes encoding SOD, APX, and CAT in tobacco, wheat, and *Arabidopsis* resulted in enhanced seed longevity. Proline has also been shown to scavenge ROS. In many plant species, proline accumulation is one of the main metabolic responses to abiotic stress.

Some protective mechanisms involving free radical and peroxide scavenging enzymes, such as catalase (CAT), peroxidase (POD) and superoxide dismutase (SOD) have been evaluated within the mechanism of seed ageing (Hsu *et al*., 2003, Goel *et al*. 2003, Pukacka and Ratajczak 2007), Loycrajjou *et al*. (2008) reported that ageing induced deterioration increase the extent of protein oxidation thus inducing loss of functional properties of proteins and enzymes. Scialabba *et al*. (2002) reported that peroxidase activity decreased in aged seeds as compare to fresh seeds in radish. Pallavi *et al*. (2003) studied that sharp decline in peroxidase enzyme during ageing in sunflower. Peroxidase and catalase activities were found higher in younger seeds of *Chenopodium rubrum* (Mitrovic *et al*., 2005). Also, Pallavi *et al*., (2003) revealed that the absorbance of dehydrogenase enzyme was decreased as the period of storage increased in sunflower. Verma et al. (2003) observed that the dehydrogenase activity was reduced as the ageing progressed and was found lowest after four years of storage in *Brassica spp*.

Changes in food reserves

In deteriorate seeds significant decrease in protein, oil content and total sugars and increase in free fatty acids and reducing sugars has been studied. (Verma *et al*, 2003) showed that carbohydrates increased with decrease in protein content in deteriorated seeds. Some studies indicated that oligosaccharide which has been associated in stabilizing membranes decreased during storage. Seed rich in lipids has limited longevity due to its specific chemical composition. During storage of oily species declining trend of total oil content and seed germination can be observed. A fatty acid composition is the most important factor which determines oils susceptibility to oxidation (Morello *et al*., 2004). Quality parameters of seed such as oil content, fatty acid composition and protein content are significantly influenced by storage conditions and time (Ghasemnezhad and Honermeier 2007). For example, sunflower seed storage demands special care due to high oil content which can easily provoke processes that can lead to loss of germination and viability.

Lipid Peroxidation

Lipid peroxidation is a complex process known to occur in both plants and animals. It involves the formation and propagation of lipid radicals, the uptake of oxygen, a rearrangement of the double bonds in unsaturated lipids and the eventual destruction of membrane lipids, with the production of a variety of breakdown products, including alcohols, ketones, alkanes, aldehydes and ethers.

Lipid peroxidation is a chain reaction initiated by the hydrogen abstraction or addition of an oxygen radical, resulting in the oxidative damage of polyunsaturated fatty acids (PUFA). Since polyunsaturated fatty acids are more sensitive than saturated ones, it is obvious that the activated methylene (RH) bridge represents a critical target site. The presence of a double bond adjacent to a methylene group makes the methylene C-H bond weaker and therefore the hydrogen in more susceptible to abstraction. This leaves an unpaired electron on the carbon, forming a carbon-centred radical, which is stabilized by a molecular rearrangement of the double bonds to form a conjugated diene which then combines with oxygen to form a peroxyl radical. The peroxyl radical is itself capable of abstracting a hydrogen atom from another polyunsaturated fatty acid and so of starting a chain reaction.

Conclusion

In conclusion, this article aims to synthesize current knowledge, address gaps in understanding and propose avenues for further research. By unravelling the secrets of seed ageing it may be contribute to the development of sustainable agricultural practices, conservation efforts and a deeper knowledge for the role of seeds play in shaping the future of our ecosystems.

References

Bogdanović Pristov, J. (2015). Maternal effect of continuous light on seed properties in a short day plant Chenopodium rubrum L.(Chenopodiaceae).

Copeland, L. O., & McDonald, M. F. (2012). *Principles of seed science and technology*. Springer Science & Business Media.

Ghasemnezhad, A., & Honermeier, B. (2007). Seed yield, oil content and fatty acid composition of Oenothera biennis L. affected by harvest date and harvest method. *Industrial Crops and Products*, *25*(3), 274-281.

Ghassemi-Golezani, K., Khomari, S., Dalil, B., Hosseinzadeh-Mahootchy, A., & Chadordooz-Jeddi, A. (2010). Effects of seed ageing on field performance of winter oilseed rape.

Goel, A., Goel, A. K., & Sheoran, I. S. (2003). Changes in oxidative stress enzymes during artificial ageing in cotton (Gossypium hirsutum L.) seeds. *Journal of plant physiology*, *160*(9), 1093-1100.

Hsu, A. L., Murphy, C. T., & Kenyon, C. (2003). Regulation of ageing and age-related disease by DAF-16 and heat-shock factor. *Science*, *300*(5622), 1142-1145.

Kapoor, N., Arya, A., Siddiqui, M. A., Kumar, H., & Amir, A. (2011). Physiological and biochemical changes during seed deterioration in aged seeds of rice (Oryza sativa L.). *American Journal of Plant Physiology*, *6*(1), 28-35.

Morelló, J. R., Motilva, M. J., Tovar, M. J., & Romero, M. P. (2004). Changes in commercial virgin olive oil (cv Arbequina) during storage, with special emphasis on the phenolic fraction. *Food chemistry*, *85*(3), 357-364.

Murthy, U. N., Kumar, P. P., & Sun, W. Q. (2003). Mechanisms of seed ageing under different storage conditions for Vigna radiata (L.) Wilczek: lipid peroxidation, sugar hydrolysis, Maillard reactions and their relationship to glass state transition. *Journal of Experimental botany*, *54*(384), 1057-1067.

Pallavi, M., Kumar, S. S., Dangi, K. S., & Reddy, A. V. (2003). Effect of seed ageing on physiological, biochemical and yield attributes in sunflower (Helianthus annuus L.) cv. Morden. Seed research-New Delhi-, *31*(2), 161-168.

Pukacka, S., & Ratajczak, E. (2007). Age-related biochemical changes during storage of beech (Fagus sylvatica L.) seeds. *Seed Science Research*, *17*(1), 45-53.

Rajjou, L., Lovigny, Y., Groot, S. P., Belghazi, M., Job, C., & Job, D. (2008). Proteome-wide characterization of seed ageing in Arabidopsis: a comparison between artificial and natural ageing protocols. *Plant physiology*, *148*(1), 620-641.

Scialabba, A., Bellani, L. M., & Dell'Aquila, A. (2002). Effects of ageing on peroxidase activity and localization in radish (Raphanus sativus L.) seeds. *European Journal of Histochemistry*, *46*(4), 351-8.

Verma, S. S., Verma, U., & Tomer, R. P. S. (2003). Studies on seed quality parameters in deteriorating seeds in Brassica (Brassica campestris). *Seed Science and Technology*, *31*(2), 389-396.

Walters, C. (1998). Understanding the mechanisms and kinetics of seed ageing. *Seed Science Research*, *8*(2), 223-244.

Volume: 04 Issue No: 12

EFFECT OF SMOKE AND SMOKE WATER ON SEED GERMINATION OF AGRICULTURAL CROPS

Article ID: AG-VO4-I12-121

R. Sindhu Lakshmi, V.Alex Albert[2] and K. Sujatha[3]*

[1]MSc Scholar, Department of Seed Science and Technology,

[2]Associate Professor, Department of Seed Science and Technology,

[3]Professor and Head, Department of Seed Science and Technology,

Agricultural College and Research Institute, Madurai-625104, Tamil Nadu, India

*Corresponding author Email Id: sujathakseed@tnau.ac.in

Abstract

Seed germination refers to the complex physiological process in which a seed transitions from a dormant state to a metabolically active state, leading to the development of a seedling. Smoke, derived from the combustion of plant materials, has been observed to contain growth-promoting compounds that can enhance germination rates and seedling vigour. Smoke scarifies the seed surface and thus breaks dormancy and enhances seed germination. Smoke and aqueous smoke extracts from burning plant materials are known for their antimicrobial property and also used in managing weeds. Application of smoke on seeds are usually in the form of smoke fumigation and smoke extracts.Smoke derived active substances may be used as agrochemicals and it also acts as plant hormones.Plant-derived smoke can improve seed germination and seedling growth, and the stimulatory effects vary depending on the type of plant utilized to make the smoke water.

Key words: fumigation, germination,smoke, vigour

Introduction

Seed germination is a critical developmental phase in the life cycle of a plant, marking the transition from a dormant seed to a growing seedling. Smoke has identified as stimulant for seed germination and seedling growth.Smoke from plant derivatives enhances seed germination, seedling growth and vigor of a wide range of agricultural and horticultural crops. One pre-requisite for the application of plant derived smoke for enhancing seed germination and seedling growth is the use of smoke must be purely obtained from burning of plant material(Dixon *et al*., 2009). Majorly in fire prone areas smoke and aqueous smoke extracts stimulates seed germination and contains many different compounds.The four major active compounds with potential agricultural use have been identified and isolated: karrikins (KARs), cyanohydrins, butenolides and hydroquinones.Butenolide [3-methyl-2H-furo(2,3-c)pyran-2-one] has been found to be the primary active germination compound of smoke-water made from burned plant materials and cellulose (Amana khatoon*et al*.,2020). It works well at extremely low concentrationsand the compound has been referred to as "karrikinolide".This chemical is responsible for smoke's ability to encourage seed germination in a variety of species. Phylogenetic location, geography, seed size, shape, and type, as well as the type of plant life—annual, perennial, herbaceous, fire-sensitive seed, or fire-tolerant re-sprouter have no bearing on the promotive effect of smoke. Germination can be aided by smoke from a wide range of biotic sources, such as wood, straw, charred wood, and combinations of fresh and dry plant material.

Smoke and Smoke water

The process of creating smoke water from burned plants involves burning agricultural cellulosic residue at a regulated air pressure and then collecting the rising smoke as bubbles in distilled water.It is possible to dilute the aqueous smoke water in the following ratios: 1:250, 1:500, 1:1000, and 1:2000 (v/v) and store it at room temperature for extended periods of time without compromising its biological activity (Abdollahi*et al*.,2012). It was determined that butenolide (3-methyl-2H-furo [2, 3-c] pyran-2-one) was the active ingredient in smoke and smoke water that aided in seed germination (Van staden*et al*.,2004). At very low concentrations (1–100 nM), this heat-stable, long-lasting, and water-soluble substance can promote seed germination and seedling growth. Butenolide can currently be manufactured artificially and is widely used as a germination and growth stimulant.

It may have implications for controlling weeds and enhancing the growth of crop seedlings. Smoke applied in the form smoke water and aerosol method increased germination and seedling vigour (Elsadek*et al*.,2019) (Govindaraj *et al*.,2016).Smoke can be applied in the form of Aerosol smoke or smoke fumigation and through smoke water or smoke extracts. Smoke fumigation is the simplest techniques for treating smoke. Direct exposure of seeds to smoke produced by burning plant matter. Smoke tents with screen trays of seeds or propagation trays of seeds sowed in soil were filled with smoke from an external combustion chamber. A metal drum with intake and exhaust pipes was used as the combustion chamber, and air was forced through it at a rate of 100 to 300 l/min.

Smoke extract

An aqueous smoke extract that was used to treat seeds was produced by bubbling smoke from burned plants through distilled water. After burning 6 kg of plant branches and foliage in a combustion chamber, the exhaust was forced into a 20-liter water tank for 60 minutes. (Water with smoke) 50 g of plant material is placed in a bee smoker, and the micro torch is used to ignite the burns. After letting the material burn for 10 to 20 seconds with the smoker open, the lid is shut and the tubing is clamped to the smoker's aperture. The water-soluble chemicals dissolve when the smoke is drawn through the flask's water. Until the entire sample is burned, more plant material is introduced to the bee smoker. The system is let to cool for around fifteen minutes after the plant material has completed burning. For analysis or seed treatments, the smoke-water solution in the side-arm flask can then be used either concentrated or diluted as necessary.

Effect of smoke on Pathogens

Smoke is recognized for having antibacterial qualities. Smoke can shield seeds and seedlings from microbial infection. Because the molecules found in smoke have chemical structures that are comparable to those of recognized fungicidal substances, they may be partially responsible for lowering the infestation of endophytic fungi. These compounds include aldehydes, aromatic hydrocarbons, and chlorine compounds.

Effect of smoke on weeds

Avenafatua, Arctotheca calendula, Brassica tournefortii, and *Raphanusraphanistrum* are among the economically significant weed species that smoke and smoke-derived compounds can effectively enhance seedlings of in agricultural systems using KAR1 treatments at field conditions at rates of 2–20 g/ha. Smoke-water can be used to stimulate the seed banks of arable weeds, and the resulting seedlings can then be eliminated before to planting the crop's seeds.

Conclusion

Plant derived smoke water has established an astonishing role in enhancing seed germination, seedling vigour, nutritional composition, breaking seed dormancy and improve the plant growth. The stimulatory effect of plant derived smoke enables plants to adopt various strategies under unfavourable conditions for protection against abiotic stresses. The use of smoke technology may be helpful in minimizing the use of chemical fertilizer inspite of improvement in understanding the response mechanisms of plants, regarding plant derived smoke, more indepth research on signaling pathways of karrikins, interaction of compounds of plant derived smoke at the cellular and molecular level of plant is yet to be unravelled.

Reference

Abdollahi, M. R. (2012). Effect of plant-derived smoke on germination, seedling vigour and growth of rapeseed (Brassica napus) under laboratory and greenhouse conditions. *Seed Science and Technology*, *40*(3), 437-442.

Dixon, K. W., Merritt, D. J., Flematti, G. R., &Ghisalberti, E. L. (2009). Karrikinolide–a phytoreactive compound derived from smoke with applications in horticulture, ecological restoration and agriculture. *Acta Horticulturae*, *813*(2009), 155-170.

Khatoon, A., Rehman, S. U., Aslam, M. M., Jamil, M., & Komatsu, S. (2020). Plant-derived smoke affects biochemical mechanism on plant growth and seed germination. *International Journal of MolecularSciences*, *21*(20),7760.

Van Staden, J., Jager, A. K., Light, M. E., & Burger, B. V. (2004). Isolation of the major germination cue from plant-derived smoke.

Govindaraj, M., Masilamani, P., Albert, V. A., &Bhaskaran, M. (2016). Plant derived smoke stimulation for seed germination and enhancement of crop growth: a review. *Agricultural Reviews*, *37*(2), 87-100.

Elsadek, M. A., & Yousef, E. A. (2019). Smoke-water enhances germination and seedling growth of four horticultural crops. *Plants*, *8*(4), 104.

Volume: 04 Issue No: 12

THE ART AND SCIENCE OF ROSE BREEDING

Article ID: AG-VO4-I12-122

[1]Alok Kumar, *[2]Ranjita Kumari and [3]Sunil Kumar Jatav

[1]Asstt. Prof.-cum-Junior Scientist, Department of Genetics, Nalanda College of Horticulture, Noorsarai, Nalanda, Bihar, India

[2]Ranjita Kumari, Ph.D. (Geography), Patna University, Patna, Bihar

[3]Scientist, Farm Science Centre, Tikamgarh, M.P., India

*Corresponding Author Email ID: ranjitarji21@gmail.com

Abstract

The art and science of rose breeding combine traditional horticultural practices with modern genetic techniques to create new rose varieties. This multifaceted discipline involves selecting for traits such as color, fragrance, and disease resistance, while employing genetic mapping and biotechnological tools like CRISPR and marker-assisted selection. By understanding the genetic basis of desirable characteristics, breeders can enhance the beauty and resilience of roses, meeting consumer demands and adapting to environmental challenges. This fusion of creativity and scientific innovation continues to shape the future of rose cultivation, ensuring that these cherished flowers flourish in gardens and markets worldwide.

Keywords: Art, CRISPR, Rose, Floribunda, MAS, QTL, SSR, SNP, Genome, Mapping

Introduction

Since ancient times, roses have enchanted people with their beauty, aroma, and symbolic meaning. These flowers play an important role in gardening, art, and culture, from the traditional red rose, which symbolizes love, to the yellow rose, which represents friendship. However, creating new rose types requires a profound grasp of genetics, horticulture, and aesthetic concepts. It also combines artistic and scientific abilities. This article explores the history, methods, difficulties, and future of the complex craft of rose breeding, delving into a fascinating field.

A BRIEF HISTORY OF ROSE BREEDING

The domestication of roses dates back thousands of years. Evidence suggests that roses were cultivated as early as 5000 BC in the Middle East and China. Early cultivators selected for specific traits, leading to the first instances of intentional breeding. The Romans and Greeks also prized roses, often associating them with their deities and using them in various ceremonies.

During the middle Ages, the cultivation of roses became more systematic, with monasteries preserving and developing various species. The Renaissance brought a renewed interest in botany and horticulture, leading to more formalized breeding practices. By this time, the hybridization of different rose species was underway, resulting in the creation of numerous varieties.

Figure 1. Rose spp.

The 19th century marked a significant turning point with the advent of modern rose breeding. Notable breeders such as Joseph Pernet-Ducher and Henry Bennett began to experiment with hybridization, focusing on colour, fragrance, and disease resistance. The introduction of the hybrid tea rose in the late 1800s revolutionized rose breeding, offering unprecedented variety and beauty.

ROSE GENETICS

Understanding the genetic makeup of roses is crucial for breeders. Roses belong to the genus *Rosa*, which encompasses over 150 species. Each species has a unique set of genes, influencing traits like flower colour, size, shape, and disease resistance. Roses typically have seven pairs of chromosomes (2n=14). The traits of roses, such as petal number, fragrance, and colour, are determined by the combination of dominant and recessive alleles. Breeders utilize this knowledge to select parent plants that possess desirable traits, combining them through controlled pollination.

HYBRIDIZATION TECHNIQUES

Hybridization is a core technique in rose breeding. Breeders can create new varieties by cross-pollinating different species or cultivars. It can be done through manually transferring pollen from one flower to another, allowing natural pollinators, such as bees, to facilitate pollination or crossing a hybrid with one of its parents to reinforce certain traits.

Hybridization has led to the development of many rose varieties, each with unique characteristics. Here are some notable ones:

a) Hybrid Tea Roses: Known for their large, high-cantered blooms and long stems, examples include Peace, Mr. Lincoln etc.
b) Floribunda Roses: These produce clusters of flowers and are known for their continuous blooming, such as Iceberg, Julia Child etc.
c) Grandiflora Roses: A cross between hybrid teas and floribundas, offering large blooms on tall plants, like Queen Elizabeth, Gold Medal etc.
d) Climbing Roses: Developed to grow vertically, examples include New Dawn, Cecile Brunner etc.
e) Shrub Roses: Known for their hardiness and disease resistance, such as Knock Out, David Austin Roses (e.g., 'Gertrude Jekyll') etc.
f) Miniature Roses: Small but vibrant varieties ideal for containers, including Baby Boomer, Little Princess etc.
g) Ground Cover Roses: Low-growing varieties that spread and cover ground, like Flower Carpet, The Fairy etc.

These hybrids have been developed to enhance traits such as colour, fragrance, disease resistance, and blooming habits.

GENETIC MAPPING AND BIOTECHNOLOGICAL ADVANCES

Advances in genetic mapping and biotechnology offer innovative solutions to enhance rose breeding, improving traits like resistance to pests and diseases, flower longevity, and overall resilience. Genetic mapping involves identifying the arrangement of genes on chromosomes and determining the specific traits they control. This process is crucial for understanding the genetic basis of traits in roses, such as flower colour, fragrance, and growth habit. Genetic mapping allows researchers and breeders to Identify Trait-Associated Genes, Facilitate Marker-Assisted Selection (MAS) and Enhance Genetic Diversity. Several techniques have been developed to facilitate genetic mapping in roses:

a) **Molecular Markers**: Markers like Random Amplified Polymorphic DNA (RAPD), Simple Sequence Repeats (SSR), and Single Nucleotide Polymorphisms (SNP) are used to identify genetic variations within populations.
b) **QTL Mapping**: Quantitative Trait Locus (QTL) mapping identifies regions of the genome associated with quantitative traits, helping in the selection of desirable phenotypes.
c) **Genome Sequencing**: Advances in sequencing technologies, such as Next-Generation Sequencing (NGS), have significantly accelerated the process of obtaining complete genomic information. The recent sequencing of the rose genome has paved the way for more detailed genetic studies.

Biotechnology encompasses a range of techniques that can modify or manipulate the genetic material of organisms. In roses, these advancements have opened new avenues for breeding and cultivation. Genetic engineering involves directly modifying the DNA of an organism. In roses, this can be achieved through Transgenic Approaches in which Genes from other organisms can be inserted into rose genomes to confer specific traits. For example, genes that impart disease resistance or enhance flower colour can be introduced to create robust varieties. Another advancement of Biotechnology is CRISPR-Cas9 Technology which is a revolutionary gene-editing tool allows precise modifications to the rose genome, enabling the deletion, addition, or alteration of specific genes. This method is more efficient and targeted compared to traditional genetic engineering techniques, and it raises fewer regulatory concerns.

Tissue culture is a method of plant propagation that involves growing plants from cells or tissues in a controlled environment. This technique is vital for Clonal Propagation and Disease-Free Plants.

THE ART OF ROSE BREEDING

While genetics provides the foundation for breeding, the artistic side is equally important. Breeders must have a keen eye for aesthetics, understanding how colours, forms, and fragrances interact. The goal is not only to create robust plants but also to develop roses that are visually striking and pleasing to the senses. Choosing the right parent plants is a critical step in the breeding process. Breeders typically evaluate potential parents based on:

a) Flower Colour: The desired hue can range from classic reds and whites to unique shades like lavender or blue.
b) Fragrance: Scent plays a vital role in a rose's appeal. Some breeders focus on enhancing fragrance, while others may prioritize bloom form and longevity.
c) Plant Characteristics: Resistance to diseases, growth habits, and hardiness are essential traits to consider, especially for commercial varieties.

THE CHALLENGES OF ROSE BREEDING

Disease and Pest Resistance

One of the significant challenges in rose breeding is developing varieties that can withstand common diseases and pests, such as powdery mildew, black spot, and aphids. Breeders often incorporate genes from wild rose species that exhibit natural resistance, a practice that requires both skill and knowledge.

Environmental Factors

Environmental conditions can greatly impact rose growth and development. Factors such as soil quality, temperature, and humidity influence the success of breeding efforts. Breeders must adapt their practices to different climates, often selecting hardier varieties for specific regions.

Market Demand and Trends

The commercial success of new rose varieties depends on market trends. Breeders must stay informed about consumer preferences, which can shift over time. For instance, there has been a growing demand for eco-friendly and sustainable varieties, prompting breeders to focus on developing roses that require fewer chemical treatments.

THE FUTURE OF ROSE BREEDING

The future of rose breeding is likely to be shaped by a growing emphasis on sustainability. Breeders are increasingly focusing on developing disease-resistant and low-maintenance varieties that require minimal chemical intervention, appealing to environmentally conscious consumers.

As technology advances, the use of genetic engineering in rose breeding may become more prevalent. Techniques such as CRISPR gene editing could enable breeders to introduce specific traits without the lengthy traditional breeding process. However, ethical considerations and regulatory frameworks will play a crucial role in how these technologies are applied.

The rose breeding community is diverse, encompassing amateur gardeners, professional breeders, and research institutions. Collaboration among these groups can lead to the sharing of knowledge, resources, and techniques, fostering innovation and enhancing the quality of new varieties.

Conclusion

The art and science of rose breeding are intertwined, creating a rich tapestry of creativity and innovation. As we move forward, breeders will continue to push the boundaries of what is a possible, producing rose that not only delight the eye and the nose but also thrive in our changing world. The legacy of rose breeding is a testament to human ingenuity and the enduring beauty of nature, ensuring that these beloved flowers will continue to bloom for generations to come.

References

Bhattacharjee, S.K. (2006). Agro techniques in field grown roses. In: Advances in Ornamental Horticulture, Vo. I, Flowering Shrubs and Seasonal Ornamentals (Bhattacharjee, S.K. ed.), Pointer Publishers, Jaipur, p. 359.

Datta, S. K. (2006) Rose breeding. Adllances in Ornamental Horticulture, Vol-l Flowering Slzrubs and Seasonal Ornamentals (Bhattacharjee, S. K. ed.) Pointer Publishers, Jaipur, Rajasthan pp.34-45.

David, H.B. (2005). Rose breeding and genetics research at Texas A & M University. The Indian Rose Annual, 21 : 52-56.

Hibrand Saint-Oyant L, Ruttink T, Hamama L, Kirov I, Lakhwani D, Zhou NN, Bourke P, Daccord N, Leus L, Schulz D, Van de Geest H, Hesselink T, Van Laere K, Debray K, Balzergue S, Thouroude T, Chastellier A, Jeauffre J, Voisine L, Gaillard S, Borm T, Arens P, Voorrips R, Maliepaard C, Neu E, Linde M, Le Paslier MC, Berard A, Bounon R, Clotault J, Choisne N, Quesneville H, Kawamura K, Aubourg S, Sakr S, Smulders R, Schijlen E, Bucher E, Debener T, De Riek J, Foucher F (2018) A high- quality genome sequence of Rosa chinensis to elucidate ornamental traits. Nature Plants. https://doi:10.1038/s41477-018-0166-1

Kaufmann H, Qiu X, Wehmeyer J, Debener T (2012) Isolation, molecular characterization, and mapping of four rose MLO orthologs. Front Plant Sci 3:244

Leus L (2017) Selection strategies for disease resistance in roses. Reference Module in Life Sciences, Elsevier. https://doi.org/10.1016/B978-0-12-809633-8.05008-1

Liang S, Wu X, Byrne D (2017) Flower-size heritability and floral heat-shock tolerance in diploid roses. HortSci 52:682–685

Liorzou M, Pernet A, Li S, Chastellier A, Thouroude T, Michel G, Malécot V, Gaillard S, Brieé C, Foucher F, Oghina-Pavie C, Clotault J, Grapin A (2016) Nineteenth century French rose (Rosa sp.) germplasm shows a shift over time from a European to an Asian genetic background. J Exp Bot 67:4711–4725

Sharma, P. and Singh AP. (2002). Multiple disease resistance against foliar diseases of roses. Indian Phytopathology 55 (2) : 169-172.

Wen, X.P., Pang, S.M. and Deng, X X. (2004). Characterization of genetic relationships of Rosa roxburghii Tratt. and its relative using morphological traits , RAPD and AFLP markers. Journal of Horticultural Science and Biotechnology, 79 (2) : 189-196.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

POSSIBLE IMPACT OF TRANS GENE ESCAPE ON BIODIVERSITY

Article ID: AG-VO4-I12-123

Dhritisikha Rajbongshi[1], Sunia Sounick[2] , Bikramjit Deuri[3] and Padminee Das[4*]

[1 and 2]B.Sc. (Hons.) Agri.4th year student, SCS College of Agriculture, Assam Agricultural University, Rangamati, Dhubri, Assam.

[3]MSc scholar, Dept of Soil Science, Indian Agricultural Research Institute, NRRI, Cuttack.

[4]Scientist (PBG), AAU-Zonal Research Station, Shillongani, Nagaon, Assam

*Corresponding Author Email ID: padminee.das@aau.ac.in

Abstract

The rise of genetically modified organisms (GMOs) has revolutionized agriculture and biotechnology, offering numerous benefits. However, it also introduces risks, one of which is transgene escape. Transgene escape occurs when genes from GMOs spread unintentionally to wild relatives or non-GM crops through mechanisms such as pollen drift, seed dispersal, or horizontal gene transfer. This could significantly impact biodiversity by potentially creating superweeds, reducing genetic diversity and disrupting natural ecosystems. Understanding transgene escape is vital for developing strategies to mitigate these risks and ensure ecosystem sustainability. This article examines the science of transgene escape, its effects on biodiversity and highlights the need for effective regulatory frameworks and continuous research to protect our environment.

Introduction

In the rapidly advancing world of biotechnology, genetically modified organisms (GMOs) promise numerous benefits, such as increased crop yields and improved resistance to pests.However, they also bring potential risks, one of the most significant being transgene escape. Transgene escape refers to a process or phenomenon through which genes from genetically modified organisms (GMOs) can escape into wild populations or non-GMO crops. It can happen via a number of processes such as cross-pollination, seed dissemination and other methods.

Transgene escape can result in a number of ecological and agricultural problems including as the emergence of weeds resistant to herbicides, possible contamination of conventional and organic crops and effects on .biodiversity. In order to avoid unforeseen consequences and preserve the integrity of both natural ecosystems and non-GMO agricultural systems, managing transgene escape is very essential. Addressing the issue of transgene escape involves rigorous scientific monitoring and the development of effective management strategies. It also requires a collaborative effort among scientists, policymakers, farmers, and the public to ensure that the benefits of GMOs do not come at the cost of our planet's ecological health.

Mechanism of transgene escape:

The escape of transgenes can be categorized into two major types based on the gene flow avenues through which the transgenes have moved and the recipients. The first category concerning the various available gene flow avenues are basically pollen mediated ,seed mediated and vegetative propagule mediated gene flow.

•Pollen-mediated gene flow – The movement of genes through pollination between individuals of different populations.

•Seed-mediated gene flow – The movement of genes through seed dispersal between different populations.

•Vegetative-propagule-mediated gene flow – The movement of genes through dispersal of vegetative organs between different populations.

For the second category, transgene flow can usually be determined as crop-to crop gene flow, crop-to-weedy gene flow, and crop-to-wild gene flow.

•Crop-to-crop transgene flow – Transgene movement from a GM crop to its non-GM crop counterpart.

•Crop-to-weedy transgene flow – Transgene movement from a GM crop to conspecific weeds.

•Crop-to-wild transgene flow – Transgene movement from a GM crop to wild relative species

Potential impact on biodiversity:

Transgene escape, where genetically modified organisms (GMOs) transfer their engineered genes into wild or non-GMO populations, can have several potential impacts on biodiversity. Here are some potential impacts on biodiversity –

1) Contamination of non GM crops : The "adventitious mixing" (also known as "contamination") of GM and non-GM crop varieties is a significant worry when transgenes are transferred from GM crops to their non-GM crop equivalents, either by seed, vegetative organ, or pollen-mediated gene flow. Concerns about food and feed safety may arise if a transgene or its derived product is found in seeds or vegetative organs of a non-GM crop intended for human consumption or animal feed. This is because transgenes are intended to change the nutritional makeup of food crops.

2) Change of genetic diversity of traditional crops: The genetic variety of traditional crops may be threatened by the widespread cultivation of genetically modified crops, which is a major source of concern (Engels et al., 2006). Crop genetic diversity decrease generally will limit the ability to produce more resilient and productive crop varieties .If transgenes have a selection advantage, their propagation through gene flow from a genetically modified crop variety to non-GM traditional varieties may alter the integrity of the traditional varieties. Hybrids with any advantageous transgenes may inadvertently accumulate over time during cultivation and seed production, eventually replacing the original genotypes of the conventional varieties through selection.

3) Issues with pharmaceutical and industrial GM crops: Crop species modified for pharmaceutical production raise worries about potential harm to humans and other species if mistakenly consumed through "co-mingling" with traditional crops in the food chain. GM crops have been adapted to behave as "bioreactors" for producing pharmaceuticals and industrial chemicals. These GM crops are expected to be unsuitable as food for human consumption because they have no historical record of safe use (Heinemann,2007). The introduction of genetically modified crops into the human food chain will likely lead to negative consequences and raise additional concerns. The hazards will be related to the original transgenic crop. Alternatively, transgenic flow may introduce new dangers since the expression of a protein in one food crop may differ dramatically from that in another.

4) Crop to wild gene flow: The most widely publicized environmental effect is that invasive weeds may emerge if GM crops designed to tolerate herbicides or resist diseases and pests transfer their transgenes to wild or weedy cousins via gene flow. Plants can also be genetically changed to grow faster (for example, by expressing a specific growth hormone), reproduce more (for example, by increasing seed output), and exist in new environments (for example, by improving drought and cold tolerance). Transgenes that improve the fitness of wild relatives, such as insect resistance, drought tolerance, or growth ability, are likely to propagate through introgression. Individuals having the transgene will outcompete those without it through natural selection. Transgenic individuals will spread quickly and become more invasive, leading to weed concerns when wild populations extend into new areas. The use of herbicide-resistant crops, such as oilseed rape, has raised public concerns about the development of "super-weeds" that can withstand several herbicides.

5) Creation of new weeds: Weeds can reduce crop quality and nutritional value by introducing undesired grains, toxins, or allergies (Kwon et al., 1991), whether from naturally occurring or genetically modified plants. Transgene-expressing weeds and wild populations provide similar management challenges as their non-transgene counterparts. Crop-to-wild transgene transfer could heighten weediness traits, resulting in increased persistence and invasiveness of existing weeds. On the other hand, a GM crop may acquire weediness genes, resulting in a crop species' toughness and invasiveness.

6) Spread of transgenic herbicide resistance: Transgenic herbicide resistance is a trait that can be easily acquired by wild and weedy species through gene flow. Weed control in crop fields is increasingly dependent on herbicides due to agricultural labor shortages and changes in farming practices. This has led to worse weed problems and weedy rice in northern China. Rice growers adopt herbicide-resistant rice varieties, but this strategy could be short-lived as resistance to different herbicides is inherited and can spread through cross-pollination.

7) Creation of landscape mosaic: The impact of a landscape mosaic created by transgene escape on biodiversity can be profound. When genetically modified (GM) crops pass their transgenes to wild relatives or non-GM crops, the resulting hybrids may possess new traits that could outcompete native species, leading to a reduction in genetic diversity. These changes can disrupt local ecosystems, as the altered plants may interact differently with pests, pollinators, and other organisms. This shift can affect entire food webs and ecological relationships, potentially leading to the decline of certain species and the proliferation of others. Overall, the unintended spread of transgenes can pose significant risks to the stability and health of natural biodiversity.

Conclusion

The Anthropocene era has markedly influenced biodiversity, with human activities such as agriculture and land use playing significant roles in this impact. The introduction of transgenic organisms and synthetic gene technologies further exacerbates the risks to biodiversity. Strengthening the precautionary principle is essential to mitigate these risks, paralleling the protective measures taken against long-lasting chemical substances in the environment. However, the current international regulatory frameworks are inadequate in preventing gene flow from genetically engineered organisms to native populations. Thus, more robust regulatory tools are necessary to enforce a global ban on the release of synthetic and transgenic organisms, particularly those with potential for uncontrolled and long-term transboundary movement. Preventive measures must also address the existing transgenes that have already escaped into the environment, with immediate action required to halt the cultivation of genetically engineered plants in regions where they risk contaminating seed-saving systems. This is crucial to prevent the inadvertent spread of transgenes within agroecological systems and to protect the integrity of natural biodiversity.

References

Lu, Bao-Rong. (2008). Transgene Escape from GM Crops and Potential Biosafety Consequences: An Environmental Perspective. *Collection of Biosafety Reviews*, icgeb.org, .

Rizwan et al. (2019). Gene Flow from Major Genetically Modified Crops and Strategies for Containment and Mitigation of Transgene Escape: A Review. *Applied Ecology and Environmental Research*, 17 (5): 11191-11208.

Bauer-Panskus, Andrea, et al. (2015). Escape of Genetically Engineered Organisms and Unintentional Transboundary Movements: Overview of Recent and Upcoming Cases and the New Risks from SynBio Organisms. *Testbiotech Institute for Independent Impact Assessment in Biotechnology*.

Pardo, Camilo Ayra. (2003). Genetically Modified Organisms and Biodiversity: Assessing the Threats. *Biotecnología Aplicada*, 20(1): 1-8.

Volume: 04 Issue No: 12

WILD RELATIVES IN CROP IMPROVEMENT

Article ID: AG-V04-I12-124

M. Arun Kumar and Narkhede Gopal Wasudeo*
Department of Genetics and Plant Breeding
School of Agriculture, SR University, Warangal – 506371, Telangana, India
*Corresponding Author Email ID: n.gopalwasudeo@sru.edu.in

Introduction

For millennia, agricultural science has been driven by the need to improve crop performance, with considerable advances made possible through selective breeding and genetic engineering. One particularly interesting area is the utilization of wild relatives for agricultural enhancement. These wild species, which are sometimes neglected in favor of their domesticated relatives, have a wealth of genetic diversity that can be used to address contemporary agricultural challenges as well. This comprehensive analysis investigates the role of wild relatives in crop improvement, focusing on their value, the methods used to incorporate them into breeding programs, as well as the associated barriers and future directions.

Importance of Wild Relatives in Crop Improvement

1. Genetic Diversity

Wild crop relatives are critical repositories of genetic variation, which is becoming increasingly important in today's agricultural world. Cultivated crops frequently have reduced genetic variability as a result of selective breeding over time. This shrinking of the genetic base makes plants vulnerable to diseases, pests, and environmental challenges. Wild relatives, on the other hand, have evolved to a wide range of environments and challenges, exhibiting characteristics that can boost the resilience and productivity of their cultivated equivalents.

For example, wild relatives of wheat, such as *Triticum dicoccoides*, have genetic variants that provide resistance to diseases such as wheat rust, which can be transferred to modern wheat types to improve disease resistance. Similarly, wild rice species such as *Oryza longistaminata* have demonstrated flood and drought tolerance, which is useful for boosting the resilience of cultivated rice.

2. Adaptation to Environmental Stress

Wild relatives can flourish in severe or changeable conditions, making them great sources of stress tolerance traits. These characteristics include tolerance to drought, salinity, and temperature extremes, which are becoming increasingly important as climate change affects global agriculture. For example, the wild species *Zea perennis,* maize related, can tolerate drought and low phosphorus circumstances. Researchers successfully introduced *Zea perennis* genes into cultivated maize, producing drought-resistant cultivars. Similarly, *Solanum pennellii*, a wild tomato species, has been used to improve drought tolerance and fruit quality in cultivated tomatoes.

3. Pest and Disease Resistance

Wild relatives frequently have unique resistance genes that are not found in developed types. Integrating these resistance genes into crops has the potential to create varieties that are more resistant to diseases and pests. One famous example is the use of *Solanum peruvianum*, a wild tomato plant, to provide resistance to the tomato brown rugose fruit virus (ToBRFV). Researchers successfully transferred desirable genes from this wild species into commercial tomato cultivars, considerably increasing their resistance to this harmful virus into cultivated tomatoes.

4. Nutritional Improvement

Wild relatives can also help improve crop nutrition. They may have higher levels of essential vitamins, minerals, and beneficial substances than cultivated versions. For example, the wild relatives *Brassica oleracea* has been used to boost the amount of glucosinolates in cultivated cabbage. Glucosinolates are known for their potential health advantages, including anticancer activity. Similarly, *Solanum tuberosum* wild relatives have been studied for their increased antioxidant content, which may improve the nutritional profile of cultivated potatoes.

Methods of Incorporating Wild Relatives into Crop Improvement

1. Conventional Breeding

A successful example of conventional breeding is the introduction of wild relatives into soybean breeding programs. *Glycine soja*, a wild soybean species, has been crossed with *Glycine max* to introduce traits such as enhanced cold tolerance and improved disease resistance.

Conventional breeding methods involve crossing wild relatives with cultivated crops to introduce desirable traits. This process, known as hybridization, can be complex due to differences in chromosome numbers or genetic incompatibilities between the wild and cultivated species.

2. Backcrossing

Backcrossing is a method that maintains the general quality of the cultivated plant while integrating characteristics from wild relatives into a cultivated variety. This procedure involves repeatedly crossing the hybrid progeny of the original cross between a cultivated variety and wild relatives with the cultivated parent. The generation of wheat cultivars resistant to leaf rust is one effective use of backcrossing. Breeders have developed wheat varieties that are more resistant to disease while retaining beneficial agronomic characteristics by backcrossing *Triticum aestivum* with *Triticum turgidum var. dicoccoides*.

3. Marker-Assisted Selection (MAS)

Using molecular markers associated with specific characteristics, marker-assisted selection allows scientists to identify and choose plants that have desirable genes. By precisely selecting plants with the desired characteristics, this method speeds up the breeding process. Utilizing markers associated with genes for disease resistance and yield enhancement, MAS has proven to be a useful technique in rice breeding. For instance, rice cultivars with increased disease resistance have been created by utilizing markers linked to wild rice resistance to bacterial blight.

4. Genetic Engineering

Through the use of genetic engineering, genes from wild relatives can be directly transferred into cultivated crops, allowing for exact manipulation. Specific qualities can be introduced using this technique in place of conventional breeding procedures. Incorporating the *Bt* gene from *Bacillus thuringiensis* into cotton is a famous instance of genetic engineering. This strategy shows how genetic engineering can be used to develop pest resistance, even when it is not directly derived from a wild relative. Incorporating genes from wild relatives for characteristics like disease resistance and drought tolerance is still being researched.

5. Genomic Approaches

High-throughput genotyping and genome sequencing, two recent developments in genomics, have given precise information into the inherited characteristics of wild relatives. This information makes genetic engineering and breeding strategies more precise. *Aegilops tauschii* is a wild relative of wheat whose genome was sequenced. This work has yielded important insights into genes involved in disease resistance and stress tolerance. Through the identification and incorporation of beneficial characteristics, wheat breeding strategies are being improved with the use of this genomic data.

Challenges and Considerations

1. Genetic Compatibility

Making sure that wild relatives are genetically compatible is one of the main obstacles in employing them. Reproductive challenges, genetic architecture, and chromosome numbers can all make integrating wild characteristics into cultivated crops more difficult. For instance, it might be challenging to develop stable and fruitful variations when crossing species with varying numbers of chromosomes since this can lead to sterile hybrids or decreased fertility. Compatibility problems like this frequently require for complex breeding methods and genetic engineering approaches.

2. Gene Flow and Biodiversity

Unintentional gene transfer from genetically modified crops to wild populations or other crops poses questions of ecological balance and biodiversity. To avoid negative impacts on natural ecosystems, it is imperative to control and regulate the use of wild relatives. According to research, non-target wild populations may be impacted by gene trasnfer from genetically modified crops, which could result in ecological changes and the possible loss of biodiversity. Maintaining ecological integrity requires both monitoring and putting into practice strategies to reduce gene flow.

3. Public Perception and Acceptance

The public and government agencies may oppose the use of wild relatives and genetic modification. The acceptance of these technologies may be influenced by public concerns regarding the safety and environmental effects of genetically modified organisms (GMOs). Gaining public approval requires effective communication and education on the advantages and security of using wild relatives and genetic modification. Consumer trust can be increased and concerns addressed with the use of transparency in research and regulatory procedures.

4. Ethical and Environmental Considerations

Concerns regarding the influence on natural ecosystems and the possibility of unexpected consequences are among the ethical issues of utilizing genetic alteration and wild relatives in agricultural improvement. Maintaining ecological balance requires making sure that conservation measures are in place to preserve wild ecosystems while making use of their genetic resources. Equitable distribution of the advantages of crop development among farmers and communities is another ethical concern, as is the responsible use of genetic resources. Sustainable agriculture methods depend on striking a balance between environmental and social responsibility and technological improvements.

Future Directions

1. Integration of Multi-Omics Approaches

Integrating transcriptomics, proteomics, and metabolomics with genomes provides a more thorough understanding of the characteristics that wild relatives have contributed. By revealing information about the connections and functions of genes, multi-omics techniques can improve the accuracy of breeding and genetic engineering techniques. For instance, by combining metabolomics and genomes, metabolic pathways linked to stress tolerance in wild relatives have been found, which has resulted in the production of crops with increased resilience. The identification and use of advantageous features can be sped up with this integrated method.

2. Advances in CRISPR Technology

New avenues for precise genetic manipulation are made possible by the CRISPR-Cas9 gene-editing technique. Researchers can accurately target and enhance crops by introducing certain genes from wild relatives into crops through the use of CRISPR. By directly altering the genomes of crops, CRISPR technology has been utilized to improve characteristics like stress tolerance and disease resistance. CRISPR, for instance, has been used to effectively improve crops by introducing genes from wild relatives that are resistant to disease into crops like wheat and rice.

3. Conservation of Genetic Resources

For crops to get better in the future, wild relatives' genetic variety must be preserved. To assure the availability of wild relatives' seeds for upcoming breeding projects, conservation efforts should be concentrated on preserving wild habitats and wild relatives' seed banks. Worldwide programs like the Global Crop Diversity Trust (Crop Trust) aim to preserve and make genetic resources from wild relatives accessible. Preserving genetic variety requires both in situ and ex situ conservation techniques, which must be supported.

4. Climate Resilience

Wild relatives with characteristics that provide tolerance to adverse weather conditions may become even more desirable as climate change offers further challenges to agriculture. The goal of research should be to find and include characteristics, such heat resistance and drought tolerance that improve climatic adaptability. Understanding the genetic underpinnings of stress tolerance and incorporating these features into breeding programs are necessary to develop crops with enhanced climate resilience. The development of climate-resilient crops can be accelerated by cooperation between scientists studying climate change, breeders, and researchers.

5. Collaboration and Knowledge Sharing

Working together, scientists, breeders, and conservationists can maximize the benefits of employing wild relatives to improve crops. Innovation and advancement in this subject will be accelerated by information and resource sharing across borders and disciplines. Collaboration and knowledge sharing are greatly aided by international research networks like the Consultative Group on International Agricultural Research (CGIAR). Innovations in crop enhancement with wild relatives can be accelerated by supporting multidisciplinary research and establishing collaborations between the public and private sectors.

Conclusion

Due to their genetic variation, ability to respond to environmental stress, resistance to pests and diseases, and improved nutrition, wild relatives are essential for crop improvement. One viable way to overcome the issues facing modern agriculture is to incorporate wild relatives into breeding programs and genetic engineering techniques. Notwithstanding the difficulties pertaining to genetic compatibility, gene flow, public opinion, and ethical issues, wild relatives may prove to be an invaluable resource in guaranteeing food security and environmentally friendly farming methods. The role of wild relatives in crop improvement will probably become even more important as research and technology continue to progress, opening up opportunities for a more robust and fruitful future for global agriculture.

References

Ellstrand, N. C., Prentice, H. C., & Hancock, J. F. (2002). Gene flow and introgression from domesticated plants into their wild relatives. In Horizontal gene transfer pp. 217-236. Academic Press.

Harlan, J. R., & Martini, M. (1994). The role of wild relatives in the improvement of wheat. Advances in Wheat Genetics; 25: 15-22.

Hirschberg, J. (2001). Carotenoid biosynthesis in plants. The Plant Cell; 13: 389-401.

Hufford, M. B., et al. (2012). Comparative population genomics of maize domestication and improvement. Nature; 490(7421): 417-424.

Hymowitz, T. (2004). The use of wild relatives in soybean breeding. Plant Breeding Reviews; 24: 55-74.

Jain, S. M., et al. (2015). Seed banks and their role in preserving plant genetic resources. Plant Genetic Resources; 12(1): 1-15.

Khush, G. S. (2001). Green revolution: The way forward. Nature Reviews Genetics; 2(10): 815-822.

Kim, J. K., et al. (2006). Glucosinolates in Brassica crops: A potential source of bioactive compounds. Plant Biotechnology Journal; 4: 435-450.

Volume: 04 Issue No: 12

AGROFORESTRY

Article ID: AG-VO4-I12-125

***Hibjur Rahman[1] and Dr. Vishwanath Sharma[2]**

[1]Junior Project Fellow, ICFRE- Rain Forest Research Institute, Jorhat, Assam

[2]Scientist-C, ICFRE- Rain Forest Research Institute, Jorhat, Assam, India

*Corresponding Author Email ID: rahmanhibjur9596@gmail.com

Introduction

Agroforestry refers to a set of land-use practices and techniques where woody plants like trees, shrubs, palms, and bamboos are intentionally integrated with agricultural crops and/or livestock on the same area. These systems can vary in spatial layout or timing of the components, fostering both ecological and economic interactions among them. This systems have often shown greater profitability compared to traditional practices and conventional cropping. By incorporating trees, these systems not only enhance income and employment for farm households but also help meet wood needs, adding valuable diversity to farming. It plays a significant role in supporting livelihoods and contributing to industrial development, making it essential to cultivate these systems carefully for long-term sustainability. It integrates trees, shrubs, and other woody plants with crops and livestock, offering a sustainable approach to land management that addresses environmental, economic, and social needs. This system helps optimize and diversify productivity, even on highly fertile lands. Intensive agroforestry practices are especially common in regions with high population density, reflecting their effectiveness and resilience as a land-use strategy. Agroforestry tourism is gaining popularity, combining elements of agriculture, forestry, ecosystems, tourism, and entrepreneurial growth. It involves visiting agroforestry sites for recreation, relaxation, education, and business development, while offering hands-on learning experiences with modern agroforestry practices and operations. This type of tourism promotes both enjoyment and practical understanding within a productive natural environment.

AGROFORESTRY IN INDIA

Globally, over 900 million people engage in agroforestry, utilizing approximately 1 billion hectares of land. Several countries, such as Brazil, China, Indonesia, and the United States, have established policies and guidelines to promote agroforestry practices. Additionally, Nepal and Bihar have implemented their own agroforestry policies to encourage sustainable land management. In India, agroforestry is practiced across 8.65% of the country's geographical area, amounting to about 28.42 million hectares. The northern hill states contribute 12.41% of India's agroforestry land. Meanwhile, the southern states, including Tamil Nadu, Andhra Pradesh, and Karnataka, have a longstanding tradition of integrated farming systems and have actively adopted agroforestry practices, reflecting their commitment to sustainable agricultural development.

CHALLENGES FOR AGROFORESTRY

Agroforestry development faces several challenges, including limited training for smallholder farmers and inadequate extension services, which hinder knowledge and adoption. Insecure land and tree tenure rights add uncertainty, discouraging long-term investments. High initial costs for seedlings and equipment can lead to early negative cash flow, while many farmers lack access to credit, further limiting adoption. Resource competition between trees, crops, and livestock also requires management skills like pruning to minimize conflicts. Long delays in returns and poor market access reduce agroforestry's appeal for quick income. Additionally, trees in agroforestry can compete with crops for sunlight and water, sometimes attracting pests. Despite these challenges, agroforestry offers benefits like soil fertility improvement, increased livelihoods, job creation, and higher productivity and income for farm households.

CHALLENGES FACING IN INDIA

Research on agroforestry models suited to diverse agro-climatic regions is limited, with few studies on indigenous, multipurpose species like *Prosopis cineraria* or on the domestication of various species. This research gap has led to an overreliance on a few species, such as Poplar, Eucalyptus, Kadam,etc. which may not meet the unique ecological and economic needs of each region.

The development of marketing infrastructure, institutional finance, and insurance for agroforestry has lagged behind its potential. This is largely due to limited awareness of the technical and economic data on different agroforestry models, which makes stakeholders hesitant to invest or adopt these practices, thereby restricting growth and sustainability in the sector.

Cumbersome and costly legislation around tree felling, wood transportation, processing, and marketing poses significant barriers for agroforestry practitioners. These regulatory challenges hinder efficient market operations, limiting the sector's growth and accessibility. Effective extension services are essential for sharing agroforestry research with farmers. However, the lack of a dedicated extension system limits access to this important information. Consequently, larger landowners often gain more from agroforestry schemes than small and marginal farmers. With two-thirds of Indian farmers categorized as small or marginal, there is an urgent need for targeted agroforestry programs to support these farmers and increase their participation in sustainable practices.

IMPORTANCE OF AGROFORESTRY

To increase the productivity of the existing land

These enhancements in yield are likely due to micro-environmental benefits provided by the trees, such as shading and nitrogen fixation. However, other studies indicate that agroforestry may be less effective than monocropping in certain situations. For instance, in Nigeria, intercropping with Leucaena trees led to a remarkable 68% increase in maize yields, demonstrating the effectiveness of agroforestry in enhancing agricultural productivity.

In Australia, pasture grass exhibited higher productivity when cultivated alongside trees. Tea yields in China 30 % higher under trees than without trees. MacDicken and Vergara (1990) reviewed 11 instances of crop yield improvements ranging from 14% to 367% under coconut trees, with an average increase of 89%. They also noted five examples of yield increases under Acacia albida, averaging 78%.

Biodiversity conservation through combination of different spp.

Agroforestry encompasses various systems that integrate different components for sustainable land management. These include:

1. ***Agrisilviculture***: This system combines crops with trees and shrubs, enhancing land productivity by utilizing the complementary benefits of both types of vegetation.
2. ***Silvopastoral***: In this arrangement, pastureland and livestock are integrated with trees, providing shade and improving forage quality while contributing to biodiversity.
3. ***Agrosilvopastoral***: This system incorporates crops, pasture, and animals alongside trees, creating a multifunctional landscape that supports diverse agricultural practices.

4. Other Systems: This category includes various innovative approaches such as multipurpose tree lots, apiculture (beekeeping) with trees, and aquaculture integrated with tree cultivation, further diversifying the benefits of agroforestry.

These arrangements optimize resource use, enhance productivity, and contribute to ecological sustainability.

Enrichment of soil health

Agroforestry practices positively impact soil health through various mechanisms. They contribute to the maintenance or increase of organic matter, which enhances soil structure and fertility. Certain tree species also facilitate nitrogen fixation, enriching the soil, while others access nutrients from deeper layers, making them available to surrounding crops. Additionally, trees capture atmospheric carbon dioxide and provide organic materials to the soil, aiding in carbon sequestration. They release growth-promoting substances into the rhizosphere, fostering plant growth. Agroforestry systems help protect against erosion through tree root stabilization and enhance nutrient-use efficiency by retrieving lost nutrients. Furthermore, these systems improve physical properties of the soil, such as structure, porosity, and water retention, and moderate extremes of soil temperature. They can also positively affect chemical properties by reducing soil acidity and salinity, thus promoting a more favorable environment for crops. The shading provided by trees benefits understorey crops by regulating soil temperature and moisture levels, ultimately improving overall soil conditions.

Carbon sequestration

Carbon sequestration is the process of removing CO2 from the atmosphere and storing it in long-lasting carbon pools. These pools include aboveground biomass (like trees), belowground biomass (such as roots and soil microorganisms), and stable forms of organic and inorganic carbon in soils and deeper subsurface layers. Durable products from biomass, such as timber, also contribute to this carbon storage. Agroforestry systems are believed to have a higher carbon sequestration potential than pastures or field crops, thanks to their diverse plant communities and complex interactions that enhance carbon storage in both biomass and soil. Numerous estimates of carbon sequestration and losses in different land-use systems exist. For agroforestry specifically, CAB Abstracts lists 266 papers—most published in the last 15 years—under the keywords "agroforestry" and "carbon sequestration." These estimates are derived by combining data on aboveground carbon stocks, often represented as half of the system's maximum carbon stock at peak age or rotation length, with the soil carbon values linked to the agroforestry system.

TYPES AND BENEFITS OF AGROFORESTRY

Taungya Farming: This is a system used for establishing forestry plantations, where annual agricultural crops are grown alongside forestry species during the early years of establishment. Typically, the land is owned by the forestry department or leased, allowing subsistence farmers to cultivate their crops. In return for tending to the forestry seedlings, these farmers can keep part or all of their agricultural produce.

Improved Fallow: This is a rotational system that utilizes preferred tree species as fallow crops, alternating with cultivated crops similar to traditional shifting cultivation. The selected trees are valued for their economic benefits or their ability to improve soil quality. Research from the World Agroforestry Centre, including studies by Jacob et al. (2013), has shown this system can effectively reduce soil erosion and enhance soil moisture using fast-growing shrubs like *Crotalaria* spp. and *Tephrosia* spp. Ideal fallow species, such as *Gliricidia sepium*, *Leucaena leucocephala*, and *Faidherbia albida* grow rapidly and efficiently recycle nutrients, thus shortening the time needed to restore soil fertility.

Live Fence: It is an agroforestry practice that uses living plants to fence farmlands, preventing animals from entering and marking property boundaries. Fodder trees and hedges are planted to protect land from stray animals and disturbances. Common species used include *Gliricidia sepium*, *Sesbania grandiflora*, *Erythrina* spp., and *Acacia* spp. Besides serving as boundary markers, these woody plants also provide a source of fuelwood for families, making this system popular among farmers.

Home Garden: This systems involve the intentional management of multipurpose trees and shrubs alongside annual and perennial crops, and sometimes livestock, within the vicinity of individual homes. Known as multitier systems or multitier cropping, these setups integrate tree-crop-animal units, intensively managed by family labor. Home gardens are highly productive, sustainable, and practical, primarily focused on food production. They feature a diverse range of trees, bushes, vegetables, and herbs, offering benefits like food security, crop diversity, improved soil fertility, and supplemental income.

Alley Farming: Alley Farming, or Hedgerow Intercropping, involves planting trees or shrubs in single or multiple rows, with crops—such as agronomic, horticultural, or forage varieties—

cultivated in the alleys between these woody plants. This system combines the benefits of both woody and herbaceous species, leading to improved soil fertility, erosion control, and diversified crop yields.

Shelterbelts: Shelterbelts are windbreaks made up of one or more rows of trees or shrubs designed to reduce wind speed, protecting farmlands, livestock, and farmsteads from wind damage and helping control wind erosion. Commonly adopted in arid and semi-arid regions, such as Nigeria, shelterbelt systems are particularly beneficial in these climates. Suitable tree species include *Azadirachta indica*, *Eucalyptus camaldulensis*, and *Acacia nilotica*.

Agrosilvopastoral : This systems combine the production of woody perennials with annual crops and pastures. This system primarily includes two forms: (a) Home Gardens, where multipurpose plants, crops, and livestock are managed around homes, and (b) Woody Hedgerows used for browse, mulch, green manure, and soil conservation. This method is valued for enhancing food security, crop diversity, and soil fertility .

Conclusion

Agroforestry plays a vital role in enhancing the prosperity of farmers and rural communities by creating jobs, generating income, ensuring food security, and meeting basic human needs sustainably. It also helps mitigate climate change while fostering integrated, diverse, and productive land-use systems. Moreover, agroforestry is the most effective strategy for increasing the country's forest and tree cover to 33%. To fully harness the benefits of agroforestry, significant investments and coordinated efforts in research, education, extension services, and effective national policies are essential. The National Agroforestry Policy of 2014 represents a major step forward in India by addressing various challenges faced by farmers and rural communities. However, a key challenge remains: effectively translating this policy from theory into practical implementation at the grassroots level.

References

Adedire MO (1992). Our vanishing rainforest ecosystem: Causes and effects. In: Role of Forestry in stabilizing fragile ecosystems of the rain forest zone of Nigeria. Akinsanmi FA (ed.). Proceedings of the 21st Annual conference of the Forestry Association of Nigeria. pp. 56 – 63.

Adekunle, V.A.J., Bakare, Y. Rural livelihood benefits from participation in the taungya agroforestry system in Ondo State of Nigeria. Small-scale Forestry 3, 131–138 (2004). https://doi.org/10.1007/s11842-004-0009-y

Dwivedi, Raghunandan & Kareemulla, Kalakada & Singh, Ramesh & Rizvi, Raza & Chauhan, Jitendra (2007). Socio-Economic Analysis of Agroforestry Systems in Western Uttar Pradesh

FAO. 2005. Realizing the economic benefits of agroforestry: experiences, lessons and challenges. Rome

Greening and Restoration of Wasteland (GROW) with Agroforestry from NITI Aayog

Kirby, Kathryn & Potvin, Catherine. (2007). Variation in carbon storage among tree species: Implications for the management of a small-scale carbon sink project. Forest Ecology and Management. 246. 208-221. 10.1016/j.foreco.2007.03.072.

Lundgren BO and Raintree JB (1982) Sustained agroforestry. In: Nestel B (ed) Agricultural Research for Development: Potentials and Challenges in Asia, pp 37-49

Nair, P. K. R. An introduction to agroforestry / P.K. Ramachandran Nair.

National Agroforestry Policy, 2014

National Agroforestry Policy, 2014, Planning Commission, 2001

Ngambeki, Dezi S., 1985. "Economic evaluation of alley cropping leucaena with Maize-Maize and Maize-Cowpea in Southern Nigeria," Agricultural Systems, Elsevier, vol. 17(4), pages 243-258.

Otegbeye, G.O. and Famuyide O.O. (2005). Agroforestry systems in the Arid and Semi-Arid lands of Nigeria: Management and Socio-Economic Importance of the Agroforestry woody species. Journal of Forestry research and Management (2):Pp 1-13

Planning Commission, 2001

Roshetko, James & Lasco, Rodel & delos Angeles, Marian. (2007). Smallholder Agroforestry Systems For Carbon Storage. Mitigation and Adaptation Strategies for Global Change. 12. 219-242. 10.1007/s11027-005-9010-9.

Sanchez, P. A. (2000). Linking climate change research with food security and poverty reduction in the tropics. Agriculture, Ecosystems and Environment, 82, 371–383.

Sharma, Prashant & Tiwari, Prabhat & Verma, Kamlesh & Singh, Manoj. (2017). Agroforestry systems: Opportunities and challenges in India. Journal of Pharmacognosy and Phytochemistry. S1. 953-957.

Sharrow, S.H. and Ismail, S. (2004) Carbon and Nitrogen Storage in Agroforests, Tree Plantations, and Pastures in Western Oregon, USA. Agroforestry Systems, 60, 123-130. https://doi.org/10.1023/B:AGFO.0000013267.87896.41

Sobola, Oluronke & Amadi, Dennis & Jamila,. (2015). The Role of Agroforestry in Environmental Sustainability. Journal of Agriculture and Veterinary Science. 8. 2319-2372. 10.9790/2380-08512025.

Valdivia, Corinne & Barbieri, Carla. (2014). Agritourism as a sustainable adaptation strategy to climate change in the Andean Altiplano. Tourism Management Perspectives. 11. 18–25. 10.1016/j.tmp.2014.02.004.

Wilson, G.V., Jardine, P.M., Luxmoore, R.J., Jones, J.R., 1990. Hydrology of a forested hillslope during storm events. Geoderma 46, 119–138.

Yu Hong, Nico Heerink, Shuqin Jin, Paul Berentsen, Lizhen Zhang, Wopke van der Werf, Intercropping and agroforestry in China – Current state and trends, Agriculture, Ecosystems & Environment, Volume 244, 2017, Pages 52-61, ISSN 0167-8809, https://doi.org/10.1016/j.agee.2017.04.019.

Volume: 04 Issue No: 12

DISEASES OF ASHWAGANDHA: STRATEGIES FOR EFFECTIVE MANAGEMENT AND SUSTAINABLE CULTIVATION

Article ID: AG-VO4-I12-126

***M. Karthikeyan, I. Johnson, T. Elaiyabharathi and T. Saraswathi**

Department of Medicinal and Aromatic Crops, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

*Corresponding Author Email ID: karthikeyan.m@tnau.ac.in

Introduction

Ashwagandha (*Withania somnifera*), also known as Indian ginseng or winter cherry, is one of the most significant and ancient medicinal plants in traditional Indian systems of medicine such as Ayurveda and Unani. It belongs to the Solanaceae family and is well-known for its wide range of therapeutic applications. The name "Ashwagandha" is derived from the Sanskrit words "ashva," meaning horse, and "gandha," meaning smell, referencing the strong odor of its roots, which are also believed to impart strength and vitality akin to that of a horse. Both the roots and berries of the plant hold immense medicinal value and are used in the preparation of herbal teas, powders, tablets, and syrups. These formulations are effective in managing various conditions, including stress, arthritis, fatigue, high cholesterol, high blood sugar, and impotence, among others.

Medicinal Importance

The therapeutic efficacy of Ashwagandha is attributed to its rich phytochemical composition, particularly its withanolides, alkaloids, and flavonoids. Withanolides, derived from the roots, are the primary bioactive compounds responsible for its adaptogenic, anti-inflammatory, and immunomodulatory properties. The plant also contains numerous alkaloids such as withanine and somniferine, amino acids, and phenolic compounds, which contribute to its medicinal versatility. As a result, Ashwagandha has been extensively utilized for enhancing healing processes, improving overall health, and reducing the severity of various chronic conditions.

Global, National, and Regional Economics

Globally, Ashwagandha is gaining immense popularity due to the growing interest in natural and herbal remedies, particularly in the nutraceutical and pharmaceutical industries. In India, it holds a prominent position in medicinal plant cultivation, with approximately 8,429 tons of Ashwagandha being produced annually from around 10,780 hectares of land. The demand for the herb has risen significantly, from 7,028 tons in 2001–2002 to 9,127 tons in 2004–2005. This increasing demand has prompted a 29.8% growth in the area under Ashwagandha cultivation, especially in Madhya Pradesh, Gujarat, Rajasthan, Maharashtra, Uttar Pradesh, Punjab, and Haryana. Madhya Pradesh, particularly the districts of Neemuch and Mandsaur, accounts for over 5,000 hectares of the total cultivation area.

In Tamil Nadu, although the cultivation area is relatively smaller compared to other states, the crop holds significant potential for expansion due to the state's favorable agro-climatic conditions and the increasing awareness of Ashwagandha's economic and medicinal importance.

Importance of Diseases in Ashwagandha Cultivation

Despite its economic and medicinal significance, Ashwagandha cultivation faces several challenges, primarily due to the prevalence of diseases. These diseases, caused by various fungal, bacterial, and nematode pathogens, lead to significant yield losses and a reduction in the quality of roots, the primary economic product. Notable diseases include leaf spot, seedling blight, root rot, and wilt, caused by pathogens such as *Alternaria alternata*, *Fusarium solani*, *Ralstonia solanacearum*, and *Meloidogyne incognita*. For instance, *Alternaria alternata* infection significantly reduces the levels of withaferin-A and withanolides, thereby impacting the medicinal value of the crop.

Eco-Friendly Disease Management

Given the adverse effects of chemical pesticides on human health, soil fertility, and the environment, eco-friendly disease management strategies are critical for sustainable Ashwagandha cultivation. Promising methods include the use of plant growth-promoting rhizobacteria (PGPR) such as *Pseudomonas fluorescens* and *Pseudomonas aeruginosa*, which have shown remarkable efficacy in reducing disease severity and promoting plant health. For example, a talc-based formulation of PGPR *Pseudomonas aeruginosa* strain WS-1 reduced disease severity by 80% in field-grown Ashwagandha. Additionally, the combined application of PGPR and chemical resistance inducers has been found to enhance root yield while suppressing soilborne pathogens such as *Fusarium solani*. Such approaches, by inducing the plant's natural defense mechanisms and promoting beneficial microbial activity in the soil, offer sustainable and environmentally safe alternatives to conventional disease control measures.

Ashwagandha's growing significance in global and national markets underscores the need for sustainable production practices to meet increasing demand. A critical component of achieving this is the effective management of diseases through eco-friendly and integrated strategies. By leveraging advances in biological control, organic amendments, and host-induced resistance, farmers can ensure the profitability and sustainability of Ashwagandha cultivation, contributing to both rural development and the medicinal plant industry.

Diseases of Ashwagandha

1. Damping-Off Disease

Causal Organism: Damping-off in Ashwagandha is caused by the soilborne oomycete *Pythium aphanidermatum*. The disease is prevalent in cool, damp environments and is especially damaging during the nursery stage of the crop. It was first reported in Uttar Pradesh in 2016, with a significant incidence rate of 15–20% in seedlings observed during the rabi seasons of 2016 and 2017.

Diagnostic Symptoms:Damping-off manifests in two stages: pre-emergence and post-emergence.

- **Pre-emergence damping-off**: Infected seedlings rot and die before they emerge from the soil surface.
- **Post-emergence damping-off**: Newly emerged seedlings topple over due to water-soaked lesions at the base of the stem. The stems become soft and mushy, leading to the collapse of the plant. Leaves initially wilt and gradually turn from gray to brown.
- Microscopic examination of infected tissues reveals encysted zoospores (10–12 µm in diameter), cylindrical sporangia, and characteristic hyaline, coenocytic hyphae.
- Severe root rotting is observed when infected seedlings are uprooted.

Survival and Spread:

- The pathogen survives in infected plant debris and spreads through contaminated water, soil, and infected seedlings.
- The disease is exacerbated by poor drainage, cool temperatures, and damp environmental conditions, which favor the survival and germination of zoospores.

Disease Management: Effective management of damping-off involves a combination of cultural, biological, and chemical methods:

- **Cultural Practices**:
  - Remove and destroy infected plants to reduce the inoculum load.
  - Ensure the use of healthy and pathogen-free seeds or seedlings.
  - Avoid overwatering and maintain proper drainage to reduce moisture in the soil.
  - Solarize nursery beds before sowing seeds to kill soilborne pathogens.
  - Rotate crops with non-host plants to disrupt the disease cycle.
- **Soil Amendments**:
  - Improve soil health by adding organic matter like farmyard manure, oil cakes, or microbial antagonists like *Trichoderma viride*.
- **Seed Treatments**:
  - Treat seeds with fungicides such as carbendazim (0.2%), thiram (0.2%), or bio-agents like *Trichoderma viride* at 6g/kg of seed.
- **Chemical Control**:
  - Fungicides such as metalaxyl-M at 0.2% concentration are highly effective, inhibiting over 90% of mycelial growth.
  - Carbendazim is also effective, with an inhibition rate of 89.67% at the same concentration.

2. Root Rot and Wilt Disease

Causal Organism: Root rot and wilt in Ashwagandha are caused by *Fusarium solani*, a devastating soilborne fungus. This pathogen causes significant yield losses ranging from 55–65% in Ashwagandha crops, particularly in warm and humid climates. The disease peaks in India during the months of April and May, causing up to 30–50% plant mortality.

Diagnostic Symptoms: The disease is characterized by a progressive decline in plant health:

- **Initial Symptoms**: Infected plants exhibit withering and drooping of leaves, followed by severe wilting.
- **Advanced Symptoms**: Roots become dark, soft, and pulpy, often accompanied by a cottony fungal growth near the plant base.
- **Seedling Stage**: Seedlings in nurseries show yellowing, drooping, and eventual rotting, leading to their complete death.

- **Field Symptoms**: Infected plants produce thin, small, and shriveled seeds, or fail to produce seeds altogether.
- **Microscopic Features**:
    - Macroconidia: Fusiform or sickle-shaped, with multiple cells.
    - Microconidia: Pyriform to ovoid, hyaline, and one- to two-celled.

Survival and Spread:

- The fungus survives as chlamydospores in soil or plant debris for extended periods.
- It spreads through contaminated soil, infected seeds, and irrigation water.
- Warm and humid environmental conditions favor the growth and dissemination of *F. solani*.
- **Disease Management**: Effective control of root rot and wilt requires an integrated approach involving cultural practices, soil amendments, and chemical treatments:
- **Cultural Practices**:
    - Remove and destroy infected plant debris and rotate crops with non-host species to reduce pathogen inoculum in the soil.
    - Maintain well-drained soil to avoid waterlogging, which promotes disease development.
- **Soil Amendments**:
    - Incorporate neem cake manure (500g/plot) into the soil, which has antifungal properties.
    - Apply organic matter and bioagents such as *Trichoderma viride* to enhance soil health.
- **Seed Treatments**:
    - Treat seeds with SAAF (carbendazim 12% + mancozeb 63% WP), neem oil, or *Trichoderma viride*.
    - A combination of seed treatment with neem cake manure and *T. viride* has shown the best results in reducing mortality and improving germination.
- **Integrated Disease Management**:
    - Combine fungicides (SAAF) with neem cake and bioagents for effective disease control.

    - Neem oil seed treatment combined with *T. viride* has been reported to reduce mortality significantly.
    - Plots treated with SAAF, neem cake manure, and *Trichoderma* showed the lowest disease incidence and highest yields.
- **Chemical Control**:
    - Use fungicides such as carbendazim or mancozeb as soil drenches or seed treatments to effectively suppress the disease.

By adopting these practices, damping-off and root rot diseases in Ashwagandha can be minimized, ensuring healthy crop growth and better yields.

Leaf Blight of Ashwagandha – *Alternaria alternata*

Causal Organism

The disease is caused by *Alternaria alternata*, a fungal pathogen that thrives in warm, humid climates and significantly impacts ashwagandha (*Withania somnifera*) cultivation.

Diagnostic Symptoms

- Initial symptoms include the development of **small, brown lesions** on mature leaves, which expand and darken over time.
- The lesions exhibit **irregular concentric rings** with a prominent **yellow halo**, especially on the upper surface of older leaves.
- In advanced stages, spots merge, leading to **severe defoliation** and a reduction in photosynthetic activity.
- Affected twigs show signs of **dieback** and **necrosis**.
- Severe infection can result in up to **80–90% infestation** of leaves, significantly deteriorating the pharmaceutical value of secondary metabolites.
- Mycelia of the fungus appear dark brown to grayish, while conidia are muriform, pale to black olivaceous, and measure **20–38 × 11–16 µm**. The conidiophores are **42.26 µm** long and **4.29 µm** wide, producing long-branched chains of conidia.

Survival and Spread

- The fungus survives as **mycelium and conidia** on plant debris in the soil and as latent infections in asymptomatic plants.
- Conidia are dispersed through **wind, rain splash, and irrigation water**, especially during high humidity and temperatures of 25–30°C.

- Alternate hosts and infected crop residues serve as reservoirs for pathogen survival.

Disease Management

1. **Cultural Practices:**
    - Removal and destruction of infected plant debris to reduce inoculum levels.
    - Crop rotation with non-host crops to prevent the buildup of the pathogen in the soil.
    - Use of well-drained fields and avoiding overhead irrigation to reduce leaf wetness.
2. **Chemical Control:**
    - **Propiconazole** and **difenoconazole** are highly effective fungicides, providing >90% inhibition of pathogen growth at 100–2000 ppm.
    - Spraying **mancozeb (0.2%)**, **Ridomil MZ (0.05%)**, or **chlorothalonil (0.2%)** effectively reduces disease intensity.
    - Carbendazim (0.05%) and copper oxychloride (1%) also provide moderate control of the pathogen.
3. **Biological Control:**
    - Application of **Trichoderma viride** and **Pseudomonas fluorescens** as biocontrol agents has shown promising results in reducing pathogen proliferation and enhancing plant vigor.
    - *T. viride* exhibited 55.66% inhibition of *A. alternata* in dual culture assays, making it the most effective bioagent.
4. **Integrated Disease Management (IDM):**
    - Combination of **farmyard manure (FYM)**, **T. viride**, and **P. fluorescens** significantly lowers disease incidence while improving dry root and seed yield.
    - Incorporation of FYM enhances soil health, making it compatible with biocontrol agents.
5. **Environmental Control:**
    - Monitoring weather conditions to predict disease outbreaks and adopting preventive fungicide applications during periods of high humidity and favorable temperatures.
    - Maintaining optimal plant spacing to ensure good air circulation.

Impact on Yield

- Severe infection leads to **50–60% yield losses**, accompanied by significant deterioration of bioactive compounds.
- Defoliation caused by leaf blight reduces the photosynthetic capacity of plants, thereby compromising overall plant health and productivity.

Research Advances

- Compatibility studies reveal that **Propiconazole + Trichoderma** formulations are highly effective in reducing disease severity.
- Studies on cultural conditions show that the growth of *A. alternata* is optimal on **CMA media at 30°C**, with minimal growth on MEA at 15°C.
- Use of natural products such as **Panchgavya** and bioagents such as **Bacillus cereus** offers additional organic options for disease control.

By implementing these strategies, the management of leaf blight caused by *Alternaria alternata* in ashwagandha cultivation can significantly improve crop yield and pharmaceutical quality.

Curvularia Leaf Spot

The leaf spot disease caused by *Curvularia lunata* is a significant issue in ashwagandha cultivation. The initial symptoms manifest as tiny, deep, dark brown necrotic spots that are typically round to oval in shape. As the infection progresses, these spots enlarge, and their centers transition from reddish-brown to brown. Eventually, the spots appear on both sides of the leaf, leading to the loss of the mucilaginous gel in the affected areas. This results in the drying and death of infected leaves, severely impacting plant health and productivity.

The fungal pathogen *Curvularia lunata* is characterized by dark olive-gray colonies with a greyish-black reverse side. Under microscopic examination, the conidiophores are observed to be long, upright, and unbranched. The conidia, which measure 18–29 × 10–8 µm, possess four transverse septa. The pathogen primarily survives on crop debris and as conidia in the soil. The disease spreads through airborne conidia, water splashes, and contaminated planting materials.

Effective management of Curvularia leaf spot includes using high-quality, pathogen-free seeds and treating them with hot water to minimize seed contamination. Crop rotation with non-host plants for at least three years is recommended to break the disease cycle. Post-harvest, infected crop residues should be buried deeply to eliminate potential sources of infection.

Additionally, maintaining proper plant spacing and avoiding overhead irrigation can reduce leaf wetness, thereby minimizing disease severity. Application of copper fungicides at a recommended rate of 2.5 kg per acre is effective in controlling the disease.

Phycomyces Leaf Spot

Phycomyces leaf spot, caused by *Pithomyces chartarum*, is another common disease affecting ashwagandha leaves. The disease is characterized by small, irregular, light brown necrotic spots, typically 5–12 mm in diameter, which develop on the abaxial (lower) surface of the leaf. In severe cases, these spots coalesce, forming large necrotic regions surrounded by bright yellow halos. On the adaxial (upper) surface, grey to black circular dots become evident, further reducing the aesthetic and physiological integrity of the leaves. Severe infections can lead to premature leaf shedding, significantly impairing plant growth.

The pathogen *Pithomyces chartarum* produces dark grey to black colonies that rapidly expand on potato dextrose agar. Conidiophores are lateral and measure 2.4–10 × 1.5–3 µm. Conidia are multicellular, dark, echinulate, and vary in shape, appearing widely elliptical, pyriform, or oblong. They measure 16–22 × 10–14 µm and develop on small, peg-like branches of the hyphae.

The survival of the pathogen in infected plant debris and soil, along with its dissemination through water, wind, and contaminated equipment, makes it challenging to manage. However, the use of resistant cultivars or pathogen-free planting materials is highly effective in reducing disease incidence. Removing and destroying infected leaves, maintaining adequate plant spacing, and optimizing irrigation practices are essential cultural practices for disease management.

Myrothecium Leaf Spot

Myrothecium leaf spot, caused by *Myrothecium roridum*, was first reported in Rajasthan, India, in 1986 by Dr. R. P. Maharishi. The disease begins with small, water-soaked areas on the leaves that are yellow to brown in color, surrounded by a chlorotic halo and a brown to violet margin. Over time, these spots enlarge and dry out, leading to defoliation in severe cases. This can significantly hinder plant growth, especially during the rainy season.

The fungal colonies of *Myrothecium roridum* exhibit rapid growth on PDA, forming a white, floccose mycelium in the initial stages. After 5–7 days, the colonies turn dark green to black with concentric rings of sporodochia that bear viscid spore masses. The conidiophores are branched, with hyaline, cylindrical conidiogenous cells measuring 10–14 × 1.5–2 µm, arranged in whorls of 3–7. The conidia are hyaline, cylindrical, and measure 6.0–7.6 × 2.2–2.8 µm, with rounded or sometimes blunt ends.

This pathogen survives on crop debris and in soil, spreading through wind, water, and contaminated tools. To manage the disease, the use of pathogen-free seeds, hot water treatment, and crop rotation with non-host plants are crucial. Deep burial of infected crop debris post-harvest is recommended to minimize inoculum in the field. Proper plant spacing and irrigation management help to reduce humidity and leaf wetness. Application of copper fungicides at 2.5 kg per acre effectively controls the disease.

Integrated Management of Ashwagandha Leaf Spot Diseases

Managing leaf spot diseases in ashwagandha requires a holistic approach that integrates cultural, chemical, and biological strategies. The use of high-quality, pathogen-free seeds and disease-resistant cultivars is the foundation of disease management. Hot water treatment of seeds can further minimize seed-borne inoculum.

Cultural practices such as crop rotation with non-host plants, removal and deep burial of infected crop residues, and ensuring proper plant spacing reduce the likelihood of disease spread. Irrigation practices should be optimized to avoid prolonged leaf wetness, and overhead irrigation should be avoided. Aligning plant rows with the direction of prevailing winds can improve airflow and reduce humidity, thereby creating unfavorable conditions for pathogen development.

Chemical control involves the use of copper-based fungicides or other recommended formulations such as carbendazim or mancozeb. Regular monitoring of fields for early detection and prompt treatment of infections is essential. Biological control agents like *Trichoderma spp.* and *Pseudomonas fluorescens* can be employed as eco-friendly alternatives to suppress pathogen activity.

By adopting these integrated disease management strategies, farmers can effectively mitigate the impact of leaf spot diseases in ashwagandha and ensure healthy crop growth and yield.

Witches' Broom Disease in Ashwagandha

Causal Organism

The causative agent of witches' broom disease in ashwagandha is a **phytoplasma**, a wall-less prokaryote that resides in the phloem of infected plants. These single-celled organisms are similar to bacteria but lack a rigid cell wall. Phytoplasmas are obligate parasites, meaning they cannot survive outside their host. They develop and proliferate in the cytoplasm of host cells, both in plants and insect vectors (Samad et al., 2011).

The disease was first identified in **Lucknow, Uttar Pradesh**, during January-February 1992 and has since spread to other Indian states, including Gujarat, Haryana, Madhya Pradesh, Punjab, and Rajasthan (Zaim and Samad, 1995).

Diagnostic Symptoms

- **Characteristic Symptoms:**The disease causes abnormal growth of the plant, with clusters of weak and dwarfed shoots emerging at or near the same location. This clustering of shoots gives the plant a "broom-like" appearance, hence the name "witches' broom."
- **Foliage Symptoms:**
    - The foliage appears unusual, often stunted and pale.
    - Leaves may exhibit chlorosis (yellowing) due to impaired phloem function.
- **Overall Growth:**
    - Plants show stunted growth, reduced vigor, and poor yield.
    - Infected plants often fail to produce flowers or fruits, drastically affecting their economic value.

The disease is particularly devastating as it disrupts the normal development of the plant, rendering it unfit for medicinal and therapeutic applications.

Survival and Spread

- **Survival:**
    - Phytoplasmas persist in the cytoplasm of phloem cells in infected plants and are transmitted to new hosts via insect vectors.
    - The pathogens can survive within the insect vectors for extended periods, ensuring continuity of their life cycle.
- **Spread:**
    - **Insect Vectors:** Phytoplasmas are primarily transmitted by **phloem-feeding insect vectors**, such as leafhoppers or planthoppers. These insects acquire the pathogen while feeding on infected plants and transmit it to healthy plants during subsequent feedings.
    - **Infected Plant Material:** The use of infected propagation materials or seeds can facilitate disease spread.

- **Wind-Assisted Insect Movement:** Movement of insect vectors by wind across fields can contribute to the rapid spread of the disease in large areas.

Disease Management

Witches' broom disease in ashwagandha can be challenging to manage due to the systemic nature of the infection. An integrated approach is necessary for effective disease control.

1. **Cultural Practices:**
   - **Removal of Infected Plants:** Prompt identification and destruction of infected plants can reduce the spread of phytoplasmas.
   - **Field Sanitation:** Maintaining a clean field by removing plant debris and weeds that may harbor insect vectors.
   - **Crop Rotation:** Avoid planting ashwagandha in fields previously infected to reduce inoculum levels.
   - **Vector Control:** Reducing populations of insect vectors through cultural or chemical methods can limit disease spread.
2. **Resistant Varieties:**
   - The development and use of **resistant cultivars** are the most effective long-term strategy. Resistant varieties prevent the proliferation of phytoplasmas, ensuring sustainable crop production (Parida et al., 2022).
3. **Chemical Control:**
   - **Antibiotics:** Chloramphenicol and chlortetracycline have been shown to inhibit phytoplasma growth. However, the use of antibiotics in agriculture should be approached with caution due to environmental concerns.
   - **Insecticides:** Applying insecticides to control vector populations can help minimize disease transmission.
4. **Thermal Therapy:**
   - Phytoplasmas can be destroyed at high temperatures (45–50°C), making thermal therapy a potential option for treating infected plant material (Parida et al., 2022).
5. **Biotechnological Interventions:**
   - Employing molecular techniques to identify resistant genes and improve ashwagandha's tolerance to phytoplasma infection.

- Use of advanced diagnostic tools like polymerase chain reaction (PCR) to detect infections early and precisely.

6. **Integrated Pest Management (IPM):**
   - Combining cultural practices, resistant varieties, vector control, and biocontrol agents to reduce the impact of the disease while minimizing environmental risks.

Witches' broom disease caused by phytoplasmas poses a significant threat to the production and medicinal value of ashwagandha. The disease's rapid spread through insect vectors and its systemic nature require a multifaceted management approach. While cultural and chemical methods can provide immediate control, developing resistant varieties and employing advanced biotechnological solutions are essential for sustainable management.

Future research should focus on understanding the biology of phytoplasmas, host-pathogen interactions, and the role of environmental factors in disease epidemiology. Identifying durable resistance genes and utilizing biocontrol agents will further enhance control strategies. A comprehensive and integrated approach will not only protect ashwagandha crops but also ensure a consistent supply of high-quality raw materials for therapeutic applications.

Root-Knot Nematode Disease

Causal Organism

The root-knot nematode disease in ashwagandha is primarily caused by *Meloidogyne incognita* (Race-2), though other species like *Meloidogyne javanica* have also been implicated. These nematodes are obligate parasites that rely on living plant cells for sustenance and reproduction. Their presence in the root system causes significant physiological and structural damage, resulting in reduced crop yield and overall plant health.

The morphology of the nematodes shows distinct sexual dimorphism:

- **Females** are pear-shaped, with wavy striae and round, offset knobs. They have no posterior protuberance, and their stylet measures about 15–16 µm in length.
- **Males** are more elongated and lack posterior protuberances. They possess rounded to oval knobs, an elevated labial disc, and no lateral lips (Perry and Starr, 2009).

Diagnostic Symptoms

The infection caused by *Meloidogyne incognita* manifests in the following ways:

1. **Root Symptoms:**
   - Formation of **galls** or knots on the roots, which are the primary diagnostic feature.

- Swollen root tissues with visible deformities such as tubers and bulbs.
- Secondary infections may occur in galled areas, further aggravating plant damage.

2. **Above-Ground Symptoms:**
   - Yellowing of leaves and stunted plant growth.
   - Wilting of the plant, even in conditions of adequate soil moisture.
   - General retardation of growth due to impaired nutrient and water uptake.

As the nematodes feed and reproduce within the plant roots, they disrupt vascular tissues, leading to systemic symptoms and a significant decline in crop yield.

Survival and Spread

- **Survival:**
  The nematodes survive as eggs or second-stage juveniles (J2) in the soil and infected plant debris. They can remain viable in soil for extended periods under favorable conditions.
- **Spread:**
  - **Soil Movement:** The nematodes are spread through contaminated soil, either via agricultural equipment or irrigation water.
  - **Infected Plant Material:** Transplanting infected seedlings or the use of infected propagules facilitates their spread.
  - **Water Flow:** Irrigation water can transport nematodes over long distances.

The nematodes' ability to survive in diverse environmental conditions and their wide host range make them highly effective pathogens.

Disease Management

Integrated disease management strategies combining cultural, biological, and chemical approaches are necessary to control root-knot nematodes effectively.

1. **Cultural Practices:**
   - **Crop Rotation:** Planting non-host crops like cereals for at least one growing season to break the nematode life cycle.
   - **Field Sanitation:** Removing and destroying infected plant residues to reduce inoculum levels.
   - **Soil Solarization:** Covering soil with transparent polythene sheets during hot weather to kill nematodes through heat.

2. **Biological Control:**Several bioagents have been found effective against *Meloidogyne incognita*:
    - **Pseudomonas fluorescens:** Soil application at 2.5 kg/ha (2.6×10^6 cfu gm^{-1}) resulted in the lowest nematode population and highest economic yield of ashwagandha (Ebhad and Patel, 2012).
    - **Paecilomyces lilacinus:** Second most effective bioagent after *P. fluorescens*, significantly reducing root galling and nematode populations.
    - **Trichoderma spp.:** Both *T. viride* and *T. harzianum* have shown strong efficacy in reducing nematode infestation and enhancing plant growth (Sharma and Pandey, 2009).
    - **Arthrobotrys oligospora:** Acts as a nematode-trapping fungus, contributing to biocontrol of nematode populations.
    - **Neem-Based Products:** Neem compounds act as nematicides and growth enhancers, comparable in efficacy to chemical treatments like carbofuran.
3. **Chemical Control:**
    - **Carbofuran:** Applied to the soil to reduce nematode infestation effectively. However, chemical control is being replaced by eco-friendly alternatives due to environmental concerns.
4. **Integrated Management:**
    - Combining bioagents like *P. fluorescens*, *T. harzianum*, and *P. lilacinus* with neem compounds and cultural practices has proven highly effective.
    - Application of organic amendments such as neem cake not only suppresses nematodes but also improves soil health.

By adopting integrated approaches and incorporating bioagents into standard practices, farmers can mitigate the impact of root-knot nematodes on ashwagandha, ensuring sustainable crop production.

Conclusion

Ashwagandha, a medicinally and economically significant crop, faces several challenges due to the prevalence of diseases such as root-knot nematode and witches' broom, among others. These diseases not only reduce the yield and quality of the crop but also impact its suitability for therapeutic applications. The causal agents, including phytoplasmas, nematodes, fungi, and bacteria, exhibit diverse mechanisms of infection, survival, and spread, complicating their management. To sustain ashwagandha production and protect its medicinal value, an integrated disease management strategy is essential. This includes the use of resistant varieties, biocontrol agents, advanced diagnostic tools, and improved cultural practices. Effective vector management, particularly in diseases like witches' broom, and the use of environmentally friendly solutions like biopesticides and neem-based compounds are also critical.

Future research should focus on a deeper understanding of pathogen biology, host-pathogen interactions, and disease epidemiology. Advances in molecular biology and biotechnology can help in identifying durable resistance genes and enhancing ashwagandha's resilience to biotic stresses. Additionally, exploring the potential of biocontrol agents, organic amendments, and precision agriculture practices will be key to developing sustainable and eco-friendly disease management solutions. The fight against diseases in ashwagandha requires a multidisciplinary approach combining traditional practices with modern scientific advancements. By mitigating the impact of these diseases, farmers can ensure a steady supply of high-quality ashwagandha for medicinal use, contributing to improved healthcare and economic sustainability.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

WORMS IN AQUARIUM HOBBY

Article ID: AG-VO4-I12-127

Berliner J[1]*, Manimaran B[2], Sellaperumal, C.[2] and Venkatesan, M.[3]

[1*]ICAR-IARI, Regional Station, Wellington, Tamil Nadu – 643231, India

[2]ICAR-IISR, Kozhikode, Kerala – 673012, India

[3]ICAR-CTRI, Research Station, Jellugumilli, Andhra Pradesh – 533466, India

*Corresponding Author Email ID: berliner.j@gmail.com

Introduction

Worms play an indispensable role in the aquarium hobby, primarily as a source of live food for fish. Among them, nematodes and the larvae of small insects are widely favored for their nutritional value and ease of cultivation. Their small size makes them suitable for feeding fry and young fish. Nematodes, such as vinegar eels and microworms (Brüggemann, 2012), are particularly beneficial for smaller fishlike fingerlings of Siamese betta and young cichlids. Similarly, insect larvae like bloodworms cater to medium-sized fish such as guppies, mollies, and platies. These live foods not only provide essential nutrients but also stimulate natural hunting behaviors, contributing to the health and vitality of aquarium inhabitants.

Vinegar Eel - *Turbatrix aceti*

Turbatrix aceti is a species of nematode that thrives in acidic environments, particularly in vinegar or fermented liquids. The vinegar eel has been used in the aquarium hobby (Hofsten et al., 1983) for many years, mainly as a live food source for small fish, fry, and invertebrates. Its presence in fermented liquids like vinegar has led to its discovery, and it has since been cultivated for use in feeding aquarium inhabitants.

Biological Description:

Vinegar eels are microscopic nematodes that measure around 1-2 mm in length. They are transparent, allowing their internal structures to be visible. Their ability to thrive in acidic environments makes them unique among nematodes. They are non-parasitic and feed on microorganisms such as yeast.

Culturing and Feeding:

The vinegar eel's lifecycle is relatively simple. They reproduce sexually and hatch from eggs, growing through several juvenile stages before becoming adults. They live in environments with high acidity, and their life expectancy is typically around a month. To culture vinegar eels in mass, a mixture of vinegar (apple cider or white vinegar) and water is used, along with some food source like yeast or other organic matter. The eels are kept in a shallow container, and the water should be slightly acidic. After a few weeks, the eels will populate the liquid, and they can be harvested using a fine mesh filter. Vinegar eels are highly nutritious for small aquarium fish, particularly fry. They provide a rich source of protein and lipids and are typically fed live, swimming in the water where the fish can easily catch them.

Microworms - *Panagrellus sp.*

Panagrellus is a genus of nematodes, with *Panagrellus redivivus* being the most commonly cultured species in the aquarium hobby. These worms are tiny, free-living nematodes. Microworms have long been utilized in aquariums, particularly for feeding small fish and invertebrates (Hofsten et al., 1983). They are often used for fry that are too small to consume larger food particles. They are also a common food source in the fish-breeding community.

Biological Description:

Microworms are slender, thread-like nematodes, measuring about 1-2 mm in length. They are free-living and thrive in moist, nutrient-rich environments. Their high reproductive rate and non-parasitic nature make them ideal for culturing as live food for aquariums.

Culturing and Feeding:

Microworms have a rapid reproductive cycle. They hatch from eggs laid by adult nematodes, and the larvae quickly grow into adults. They reproduce by laying eggs, and their lifecycle can be completed in just a few days under the right conditions. Microworms are cultured in a moist medium such as oatmeal or potato flakes, which provides food for the worms. The culturing container should be kept in a warm environment, and the worms should be harvested with a small scraper or spoon. Fresh culture medium is often added to maintain the worms' population, ensuring a continuous supply. Microworms are small and can be fed directly to fry or small fish. They are an excellent live food option as they swim actively and are easy for the fish to catch. These worms provide essential protein and nutrients, which are especially beneficial during the early stages of fish development.

Grindle Worm – *Enchytraeus buchholzi*

Enchytraeus buchholzi, commonly known as Grindle worms, are small white worms that thrive in moist environments rich in organic matter. They are closely related to earthworms and are highly valued in the aquarium hobby as a nutritious live food source, especially for small to medium-sized fish. Their high protein content makes them ideal for conditioning fish or feeding fry (www.qualitymarine.com).

Biological Description:

Grindle worms are annelids, measuring about 5-10 mm in length. They are segmented and have a whitish, translucent appearance. They inhabit damp, nutrient-rich substrates and consume organic material such as decaying plant matter and microorganisms.

Culturing and Feeding:

Grindle worms are easy to culture and require minimal setup. A shallow container with damp substrate, such as soil, cocopeat, or damp paper towels, is typically used. The container should have some ventilation to prevent mold growth. Grindle worms can be fed oatmeal, bread, or other organic matter, which should be lightly moistened. It is crucial to avoid overfeeding to prevent food from rotting and harming the worms. Regular harvesting can ensure a consistent supply of worms while maintaining a healthy culture. Grindle worms are an excellent live food choice for aquarium fish. They wiggle enticingly in water, stimulating the fish's natural predatory instincts. They are particularly beneficial for growing fry or improving the health and coloration of adult fish. The worms can be rinsed before feeding to ensure cleanliness.

Tubifex Worm – *Tubifex tubifex*

Tubifex tubifex are slender, reddish worms commonly found in nutrient-rich aquatic sediments. Known for their tolerance to polluted environments, they are widely used in aquariums as live food for fish, offering a high-protein diet. However, due to their habitat, they can sometimes carry pathogens, so proper handling is crucial.

Biological Description:

Tubifex worms are annelids, measuring up to 2 cm in length. They have a reddish color due to the hemoglobin in their bodies, which allows them to survive in low-oxygen environments. These worms form dense colonies in muddy or silty water.

Culturing and Feeding:

Culturing Tubifex worms requires a container with a substrate of nutrient-rich mud or organic material. The container should have shallow water with minimal flow to mimic their natural environment. Organic waste, such as vegetable scraps, can be used as food. It is essential to ensure the water remains oxygenated and the culture is regularly cleaned to prevent disease buildup. Over time, the worms will multiply, forming dense clusters that can be harvested. Tubifex worms are highly palatable to most fish species. Before feeding, they should be thoroughly rinsed to remove any potential contaminants. Fish eagerly consume live Tubifex worms, which provide an energy-rich meal. They are particularly useful for carnivorous and omnivorous fish species.

Bloodworm – *Chironomidae Larvae*

Bloodworms, the larvae of non-biting midges, are bright red due to the presence of hemoglobin, which allows them to survive in low-oxygen environments. Found in nutrient-rich, stagnant water, bloodworms are a popular food source for aquarium fish and are available in live, frozen, or freeze-dried forms (www.ouraquariumlife.com).

Biological Description:

Bloodworms are insect larvae, measuring 10-15 mm in length. Their bright red coloration is due to hemoglobin, which aids in oxygen transport and storage. They inhabit stagnant or slow-moving water bodies and feed on detritus and organic matter.

Culturing and Feeding:

Bloodworms can be cultivated by creating a habitat that mimics their natural environment. A shallow container with decaying organic material and stagnant water can encourage midge eggs to hatch into larvae. Aeration should be minimal to simulate low-oxygen conditions. It is essential to maintain water cleanliness to prevent foul odors and the buildup of harmful bacteria. The larvae can be harvested with a fine mesh net. Bloodworms are a rich protein source and are widely used as a staple diet for aquarium fish. They are highly enticing to fish due to their bright color and active movement in the water. Live bloodworms are especially beneficial for carnivorous and predatory fish. Care should be taken to handle them properly, as some individuals may develop allergies when in contact with bloodworms.

Comparative Overview

Worm Type	Size	Culturing Medium	Best for	Nutritional Value
Vinegar Eels	1-2 mm	Vinegar and water	Small fry	Protein and lipids
Microworms	1-2 mm	Oatmeal or potato flakes	Fry	Essential proteins
Grindle Worms	5-10 mm	Damp soil or cocopeat	Small to medium fish	High protein content
Tubifex Worms	Up to 2 cm	Muddy or silty substrate	Carnivorous/omnivorous fish	High energy and protein
Bloodworms	10-15 mm	Decaying organic material	Carnivorous/predatory fish	High protein

Cons of Using Live Worms

While live worms provide excellent nutrition for aquarium fish, they also come with some disadvantages. The primary concern is the potential introduction of pathogens or parasites into the aquarium, particularly when culturing methods are not hygienic. Additionally, overfeeding live worms can lead to water quality issues due to uneaten food decaying in the tank. Proper handling and careful monitoring of both the worms and the aquarium environment are essential to mitigate these risks.

References

Brüggemann, J. 2012. Nematodes as Live Food in Larviculture – A Review. Journal of the World Aquaculture Society. 43(6): 739-763 . 10.1111/j.1749-7345.2012.00608.x.

Hofsten, A. V., Kahan, D., Katznelson, R. and Bar-El, T. 1983. Digestion of free-living nematodes fed to fish. Journal of Fish Biology, 23:419-428.

https://www.qualitymarine.com/news/homegrown-food-the-greatness-of-grindal-worms/

https://www.ouraquariumlife.com/fish/blood-worms/

Volume: 04 Issue No: 12

WATER STRESSED AREA TRANSFORMED INTO ENERGY RICH HIGH VALUE PRODUCE HUB THROUGH FRONTLINE EXTENSION

Article ID: AG-VO4-I12-128

***J P Mishra[1], H N Meena[2], N K Gupta[3] and R K Yadav[4]**

[1-]Director, ICAR-ATARI, Jodhpur, [2-]Principal Scientist (Agronomy),

ICAR-ATARI, Jodhpur, Rajathan, India

[3&4] Subject Matter Specialists, KVK-Jaipur-I, Chomu Jaipur, Rajathan, India

Corresponding Author Email ID:* mishrajaip@gmail.com

Abstract

Rajasthan is one of the most water stressed state of India. In the past, several initiatives have been taken by the Central and State Governments to augment the water availability especially through harvesting of surface water. The decline in groundwater status in different districts of Rajasthan including Jaipur have been rampant. Total annual groundwater recharge of 12.45 BCM was estimated in Rajasthan during 2023 and 11.25 BCM annual extractable groundwater resource. Against this, total 16.74 BCM groundwater was extracted resulting into 149% groundwater development (M/o Jalshakti, GoI, 2023). This is an alarming situation leading from stress to scarcity in many geographies in India and necessitated for new practices with a suitable blend of new technologies and traditional wisdom to enhance sustained rainwater harvesting for enhanced land productivity. Both Central and State Governments have been incentivizing farmers for establishing the farm ponds at their fields under several centrally sponsored schemes and State sponsored schemes. The noticeable initiatives are National Mission for Sustainable Agriculture (NMSA), Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Rastriya Krishi Vikas Yojana (RKVY) and Khet Talai Yojana. The Khet Talai Yojana of Government of Rajasthan paid a rich dividend to the farmers. A study of selected farm households of three villages of Nagal Bharda, Nagal Koju and Kanwarpura under Jotwara block of district Jaipur, Rajasthan was conducted during 2023 to assess the impact of frontline institution-led interventions on productivity, crop diversification, groundwater recharge and income of farmers of farm ponds. The data of 54 beneficiaries, 18 each from three villages were collected for cropping pattern, productivity and income of farm households before and after water positive interventions. The water positive interventions influenced cropping with 2 to 55.1 % increase in cropped area during kharif cropping and 37% to 200% increase in cropped area. The crop productivity enhanced from 19.3 to 41.2% in kharif and 22 to 100% in rabi crops. The diversification towards groundnut and cluster bean was recorded in kharif season with area augmentation of 9.5% to 40.4% and in favour of chickpea in rabi season. Increase in productivity ranged from 31.5 to 44.4% due to enhanced water availability for protective irrigation. The diversification towards vegetables (tomato, chilies, cauliflower, cabbage and cucumber) with area increase by 63.5 to 600% post-farm ponds establishment was the most significant for income augmentation of farmers. The productivity of the vegetables increased by 21% to 100% as compared to those obtained in pre-farm pond period. The cumulative impact on income of farmers reflected with annual increase ranging from 98% to 345.7% due to farm ponds.

Key words: farm ponds, water, cropping, productivity, income, intensity.

Introduction

The Khet Talai Yojana was initiated by Government of Rajasthan in 2015-16 for recharge of old tube wells as well as creation of farm ponds for storage of rain water for irrigation of crops. The farmers, in the severe ground water depleted areas, have taken advantage of the scheme. One such area in Jaipur Rural district is Niwana agriculture circle. These initiatives have helped augmenting water storage and enhance area under irrigation through protective irrigation in rainy and post rainy seasons cropping. The farm ponds also work as sink for surplus water during the monsoon which otherwise lost through runoff. The farmers over the years have been cultivating pearl millet, greengram, groundnut, cluster bean and sorghum etc. during kharif season and wheat, barley, mustard, gram and taramira in rabi season with little of vegetables like tomato, cauliflower and cucurbits and aonla as fruit crop. As groundwater table status dropped from 30-39 metres in 2010 to 225 to 267 meters 2018, the cropping became difficult in rabi season due to non-availability of

Farm Pond at Village Kanwarpura

water for irrigation. A turn around was noticed after the farm ponds were established under Khet Talai Yojana with overall transformation of agricultural landscape of the villages well received by the farmers. The frontline extension institutions in Rajasthan and Jaipur district played a catalytic role and helped the farmers in selection of crops and varieties, provided quality planting materials and seeds and training to farmers for nursery raising, use of efficient water application tools such as sprinklers and drip systems, water conservation measures and hi-tech protected cultivation, etc. The present study has been conducted to assess the impact of decentralized water harvesting intervention on cropping intensity, crop diversification and socio-economic development of the farmers in three villages of Jaipur district.

Farm Pond at Village Nangal Bhards village

Study Area: Jaipur district is chronically water stressed. During last decade the groundwater level in the rural areas has fallen by 25 meters. District has 13 blocks and all have been classified under dark zone by the Central Ground Water Board (CGWB). The groundwater table in Amber block fell by 23.2 metres, in Bassi by 18 metres, Govindgarh and Jothwara blocks by 17 metres during 2004 to 2014 and continuously depleting. Pearl millet, greengram, groundnut, cluster bean and sorghum are major field crops of kharif and wheat, barley, mustard, chickpea and taramira of rabi season. Amongst horticultural crops, tomato, chilli, cabbage, cauliflower and cucurbits are important vegetables and aonla amongst fruits. Prior to farm ponds scheme farmers were not using micro-irrigation system.

However, after 2015-16, majority of the farmers have adopted sprinkler in field crops and drip in vegetables and orchards. Niwana is one of the 23 agriculture circles of Jotwara block of Jaipur districts which was taken up for the study of impact of farm ponds created under Khet

Talai Yojana. Three villages Nagal Bharda, Nagal Koju and Kanwarpura were selected for the data collection. Total 54 farm households, 18 beneficiaries each from Nangal Bharda, Nangal Koju and Kanwarpura villages were selected randomly for the study. The farmers were interviewed with the help of structured schedule prepared for the purpose. Primary data of pre and post farm ponds establishment were collected.

Soil and water of study area: The soil of the study area is loamy sand with low water holding capacity. The profile of cropping before and after farm ponds was collected from individual farmers and verified through focused group discussions.

Table 1: Key indicators of the sampled villages

Indicators	Units	Nangal Bharda	Kanvarpura	Nangal Koju
Population	Number	6399	3282	5280
Families	Number	920	494	733
Geographical Area	ha	1503.3	585.0	942.0
Water Table in 2010	metre	30-37.5	33-39	31.5-37.5
Water Table in 2018	metre	225-261	240-267	234-255

The reported depth of groundwater table was 30-39 meters during 2010. Due to overexploitation and non-judicious use of water for irrigation, the water table declined to 225 to 267 meters in 2018. The average decline of 21-24 meters per year was recorded in the groundwater table. The scarcity of irrigation water led to reduction in post-rainy season cropping by 60 to 70%

Interventions of KVK:

The farmers in majority used to take single crop in year before the farm ponds scheme was implemented due to scarcity of water crops. The area under vegetable crops was decreasing and productivity was dismally low. The KVK, Jaipur-I motivated the farmers to install drip irrigation and adopt mulching in vegetable cultivation and trained the farmers of these villages about precise use of irrigation water. Focused group discussions and demonstration at farmers' fields on high yielding short duration varieties of field crops and hybrids of vegetables were organized to convince the farmers. Initially, farmers were facilitated with quality planting materials and seed produced at the KVK farms on nominal charges. They were also linked with the seed agencies and the district agriculture department for availing incentives for micro-irrigation systems and quality seeds under various development programs. The subject matter specialists of KVK regularly visited farmers' fields for monitoring the activities and motivating the farmers. The cropping pattern and intensity changed after construction of farm ponds and farmers started raising two or more crops particularly vegetable crops with more area in subsequent years.

Interventions of KVK at farmers fields for mositure conservation and high value cropping

Cropping pattern and Intensity

The cropping profile of three villages undergone considerable change owing to implementation of farm ponds. While cereal-cereal –oilseed (pearl millet/fodder-wheat/barley/mustard/taramira) was the predominant cropping pattern of the villages prior to farm pond's introduction, the diversification in favour of chickpea and vegetables happened after farm ponds creation. The enhanced water availability for protective irrigation was the resource trigger and motivation of farmers with new seeds of improved varieties and quality planting materials provided by the KVKs was the technology triggers for this diversification in cropping. The CFLD on pulses under ICAR-ATARI-DAFW collaboration motivated farmers for adoption of chickpea which was not cultivated earlier by the sampled farmers.

Table 2: Cropping pattern pre and post farm ponds establishments in three villages

Cropping	Nangal Bharda (n=18)	Nangal Koju (n=18)	Kanwarpura (n=18)
Total cultivated area of village (ha)	1503.3	585.0	942.0
Net cultivated area of sampled farmers (ha)	**54.75**	**47.8**	**39.75**

Field cropping before farm ponds	Pearl millet /bajra (f)-wheat/barley mustard	Pearl millet /bajra (f)/groundnut/ cluster bean- wheat/ barley/mustard/ taramira	Pearl millet/ bajra (f)/ cluster bean-wheat/barley/ mustard
Field cropping after farm ponds	Pearl millet/ bajra (f) wheat/barley mustard	Pearl millet /bajra (f)/groundnut/cluster bean- wheat/barley/ mustard/ taramira/ chickpea	Pearl millet/ bajra (f) / cluster bean-wheat/ barley/ mustard / chickpea
Diversification	No change in crop profile in either season	Farmers adopted chickpea in rabi season	Farmers adopted chickpea in rabi season
Vegetable Cropping before farm ponds	Tomato/chilli/ cabbage	Tomato	Tomato
Vegetable Cropping after farm ponds	Tomato/chilli/cabbage/ cucumber	Tomato/chilli/cualiflower/ cucumber	Tomato/chilli/ cucumber
Diversification	Cucumber under protected cultivation	Chilli and cauliflower (open field), cucumber (protected cultivation)	Chilli open field and cucumber (protected)

Crop Selection and Seasonal Variations:

A marginal increase of 6% in area was recorded together for pearl millet and bajra fodder while groundnut and cluster bean recorded negative growth of 9 to 29% as compared to pre-farm ponds establishment. The farmers switched over to fine cereal like wheat, oilseeds -mustard and taramira and vegetables due to higher price and augmented income realization. During rabi season, the area increase under fine cereal wheat was almost twice (65%) as compared to 35% in coarse grain-barley. The higher price signals under MSP and disallowing blending in mustard oil leading to better market price of mustard were the policy triggers while demonstrations on HYVs of mustard with full package under CFLDs proved technology trigger causing 161% increase in area of mustard post farm ponds establishment. Another localised edible oilseeds taramira registered an increase in area by 200% due to industrial demands. Chickpea is the new crop introduced with the sampled farmers post farm ponds establishment after the interventions of CFLDs on chickpea.

Table 3: influence of introduction of farm ponds on cropping area under different crops

Crops and Season	Pre-farm ponds cropped area (ha)	Post-farm ponds cropped area (ha)	Change (%)
Field Crops in kharif season			
Pearlmillet	53.90	55.00	2.0
Groundnut	2.30	2.10	(-) 9.5
Clusterbean	7.30	5.20	(-) 40.4
Fodder Bajra	4.45	6.90	55.1
Field Crops in Rabi season			
Taramira	0.50	1.50	200.0
Mustard	5.90	15.40	161.0
Chickpea	0.00	1.90	100.0
Barley	11.90	16.30	37.0
Wheat	16.70	27.50	64.7

High Value Cropping

The farm ponds establishment brought a true revolution in high value crops and introduction of protected cultivation for cucumber. Cauliflower and cucumber are the new introduction amongst farmers with the interventions by KVKs for quality planting materials and training and capacity development. Area under tomato increased by 64%, cabbage 153% and chilli by 600% due to enhanced water availability for vegetable cultivation in the villages (Table 4)

Table 4: influence of introduction of farm ponds on cropping area under different crops

High Value Crops *Vegetable*	Pre-farm ponds cropped area (ha)	Post-farm ponds cropped area (ha)	Change (%)
Tomato	17.00	27.80	63.5
Chilli	0.70	4.90	600.0
Cauliflower(Seed Production)	0.00	1.50	100.0
Cabbage	1.50	3.80	153.3
Cucumber	0.00	2.40	100.0

Cropping Intensity

The cropping intensity saw a sea change due to farms ponds and availability of water for irrigation assuring double cropping. Amongst the different categories of farm holdings, the highest positive change of 76.1% noticed in the marginal farmers (Table 5) while medium to large holdings recorded the lowest changes in cropping intensity. The results indicated that the farm ponds scheme delivered significantly for the small and marginal farmers who require it the most.

Table 5: Response of holding size to change in cropping intensity

Category	Range of holding	Number of farmers	Cropping Intensity		Change
Medium to large	4.0 to 15.0	5	61.7	77.1	15.4
Medium farmers	2.0 to 4.0	14	79.8	108.3	28.6
Small	1.0 to 2.0	32	105.3	154.7	49.4
Marginal	less than 1 ha	5	110.9	187.0	76.1

Productivity and Income of Households

The productivity of kharif crops viz, Pearlmillet, Groundnut, Clusterbean, Fodder Bajra increased by 41.2, 31.5, 44.4 and 19.3%, respectively after the introduction of farm ponds. The increase in productivity was in the order of 100% in taramira and chickpea to 22% in wheat, 24.7% in barley and 44.1% in mustard during winter season cropping. The productivity of vegetables increased from 21.3% in tomato to 100% in cucumber and cauliflower which were a new introduction in the studied villages.

Table-6: Effect of farm ponds on productivity of crops in sampled villages

Crops	**Productivity (q/ha)**		**Per cent change**
	Before Farm Pond	After Farm Pond	
Kharif			
Pearlmillet	12.56	17.74	41.2
Groundnut	14.83	19.50	31.5
Clusterbean	10.00	14.44	44.4
Fodder Bajra	220.00	262.08	19.3
Rabi			

Taramira	5.00	10.00	100.0
Mustard	12.86	18.53	44.1
Chickpea	0.00	16.50	100.0
Barley	39.41	49.14	24.7
Wheat	40.94	49.96	22.0
Vegetables			
Tomato	226.59	274.17	21.0
Chilli	81.67	160.38	96.4
Cauliflower (Seed Production)	0.00	5.00	100.0
Cabbage	213.33	303.50	42.3
Cucumber	0.00	220.00	100.0

Significant increase in income of the farmers was reported. The income of the households of studied farmers in three villages ranged from Rs 7000 to 127500/year in Nangal Koju to Rs 53000-260000/year in Nangal Bharda and 27000-99000/year in Kanwarpura before the introduction of farm ponds which increase substantially ranging from 345.7 to 156.5% in Nangal Koju to 11.3 to 119.2% in Nangal Bharda and 133.3 to 98% in Kanwarpura after the introduction of farm ponds (Table 7).

Table-7: Increase in household income of the sampled farmers

Village	**Income of farmer before farm pond (Rs./year)**		**Income of farmer after farm pond (Rs./year)**		**Change in Income (%)**	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
Nangal Koju	7,000	127500	31,200	32,7000	345.7	156.5
Nangal Bharda	53,000	260,000	112,000	570000	11.3	119.2
Kanwarpura	27,000	99000	63,000	196,000	133.3 0	98.0

Conclusion

The study of select farm households of three villages, Nangal Bharda, Nangal Koju and Kanwarpura in Amber block of Jaipur Rural districts established the importance of water in agriculture and the positive impact brought about through the Khet talai Yojana of Government of Rajasthan. The all-round improvement in cropping area and intensity, productivity and income of the households brought prosperity in these villages and the villages which were turning into a low productivity region transformed into a highly diversified agricultural production hub of energy rich and high value crops. This is a classic example of an integrated effect of ‘pull’ and push effect for agricultural diversification through three dimensional triggers for augmenting farm resources in the form of farm ponds, policy triggers in the form of price signals and disallowing blending in mustard oil and technology triggers carried out by frontline extension agencies for pulses, oilseeds and high value crops and hi-tech horticulture.

Volume: 04 Issue No: 12

PLANT-BASED BEVERAGES: CHALLENGES AND INNOVATIONS

Article ID: AG-V04-I12-129

Keerthana V, Mohamed Thofic N, *Krishanakumar P. C.K.Sunil, N.Venkatachalapathy
National Institute of Food Technology, Entrepreneurship and Management, Thanjavur (NIFTEM-T), Tamil Nadu, India
*Corresponding Author Email ID: krishnakumar@iifpt.edu.in

Abstract

The rise in demand for plant-based beverages reflects a broader shift toward more sustainable, health-conscious consumption patterns. While innovative developments are emerging in this sector, several challenges hinder its growth. This article explores the challenges faced by the plant-based beverage industry, highlights innovations that are addressing these issues, and proposes unique ideas for future development.

Introduction

The plant-based beverage market has witnessed significant growth in recent years, driven by various factors, including health trends, environmental concerns, and ethical considerations pertaining to animal welfare. These beverages encompass a wide range of products, from nut milks and soy drinks to herbal infusions and cold-pressed juices. However, despite the booming demand, the industry faces several challenges, along with a plethora of opportunities for innovation. This article aims to dissect these dimensions and provide insights into potential future developments.

1. The Landscape of Plant-Based Beverages

1.1 Market Overview

The global plant-based beverage market is projected to reach new heights, with consumer preferences shifting toward products perceived as healthier and more environmentally friendly. A report by Grand View Research estimates that the market will expand significantly by 2027, driven largely by the increasing prevalence of lactose intolerance, vegan diets.

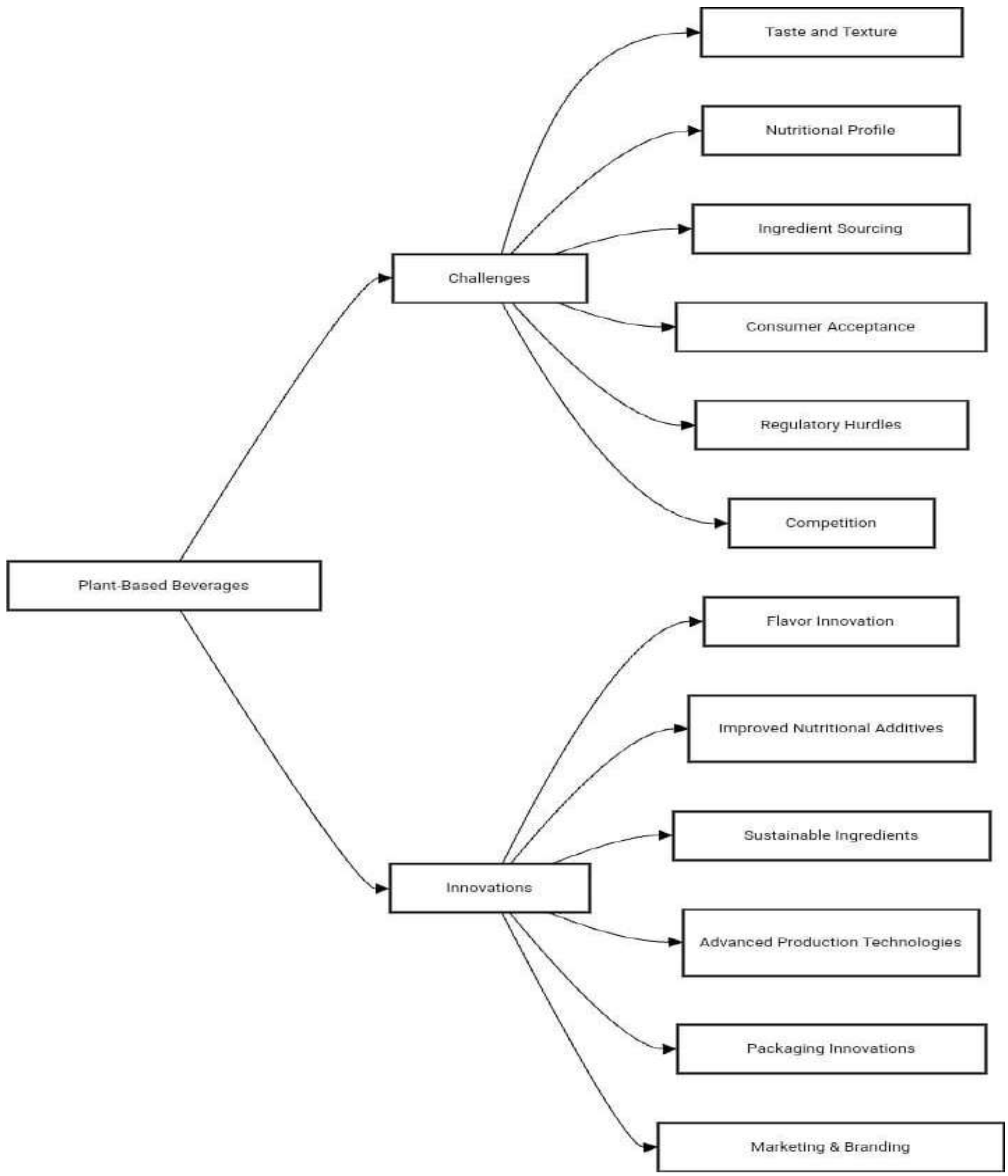


Fig.1. Plant Based Beverages Challenges and Innovations

1.2 Consumer Preferences

Understanding consumer behaviour is crucial for product development, marketing, and branding. Today's consumers desire clean labels and transparency regarding ingredient sourcing. They are also increasingly conscious of the environmental impact of their choices, making eco-friendly packaging an attractive selling point.

2. Challenges Facing the Industry

2.1 Ingredient Sourcing and Quality

One of the primary challenges in the plant-based beverage sector is the sourcing of high-quality, sustainable ingredients. Many plant-based drinks rely on specific crops such as almonds, soybeans, and oats, which can lead to supply chain vulnerabilities. Issues such as climate change, water scarcity, and agricultural practices pose significant risks.

2.2 Nutritional Profile and Functionality

The nutritional profile of plant-based beverages can be questionable. Many products lack essential vitamins, proteins, or minerals found in cow's milk or other animal-based beverages. They often require fortification (e.g., with calcium or vitamins B12 and D) to meet consumer expectations for nutrition, complicating the product formulation process.

2.3 Taste and Texture

Creating appealing taste and texture is vital for consumer acceptance. Many consumers have specific preferences regarding the mouthfeel and flavour profile of beverages. Self-branded offerings often lack the creamy, rich textures found in traditional dairy products, leading to possible dissatisfaction.

2.4 Regulatory and Labelling Challenges

Navigating regulations around labelling can be a significant hurdle. Terms like "milk" in products derived from plants face scrutiny and regulatory pushback, which limits marketing potential and creates confusion for consumers.

3. Innovations in Plant-Based Beverages

3.1 Advances in Ingredient Processing

Innovations in food technology are revolutionizing the ingredient processing methods to enhance flavour, texture, and nutritional content. For instance, ultrafiltration techniques can concentrate proteins, improving the nutritional profile without compromising taste.

3.2 Cultured and Fermented Beverages

The fermentation process has gained traction, leading to probiotic-rich products such as plant-based yogurts and kefir. Fermentation enhances the nutritional profile, contributes to gut health, and can result in unique flavour profiles appealing to consumers.

3.3 Sustainable Packaging Solutions

As environmental concerns grow, packaging innovations, such as biodegradable or reusable packaging options, are taking centre stage. Companies are now exploring plant-based packaging materials aimed at reducing plastic waste, appealing to eco-conscious consumers.

3.4 Personalized Nutrition

The rise of AI and data analytics has given rise to personalized nutrition products, opening the door for tailor-made plant-based beverages. Companies leveraging artificial intelligence can analyse individual dietary needs and preferences to create unique beverage options, enhancing consumer engagement.

4. Unique Ideas for Future Development

4.1 Regional Plant-Based Beverages

Exploring lesser-known regional plants specific to various cultures can lead to the creation of distinctive flavours while offering economic opportunities for small farmers. For instance, beverages made from indigenous seeds or fruits could open new markets and foster cultural appreciation.

4.2 Co-creation with Consumers

Brands can leverage social media platforms to engage with customers in the product development process. Inviting consumers to submit ideas for flavors or ingredients can lead to innovative offerings and foster a sense of community, thereby enhancing brand loyalty.

4.3 Educational Initiatives

As part of their marketing strategy, companies can promote the health benefits of plant-based beverages through workshops, interactive events, and social media campaigns. Educating consumers about the nutritional and environmental advantages could help overcome skepticism.

4.4 Subscription Models

The introduction of subscription-based services can cater to convenience-seeking consumers while ensuring regular consumption. Curated boxes that provide seasonal or regionally inspired plant-based beverages allow for experimentation and adaptation based on consumer feedback.

5. Future Trends and Innovations

5.1 Leveraging Technology for Sustainability

Digital technologies like blockchain can be employed to ensure transparency in sourcing and production processes, helping to track the sustainability of ingredients. This transparent approach aligns with consumer preferences for responsible sourcing and ethical consumption.

5.2 Plant-Based Beverage Mixology

The intersection of mixology with plant-based beverages offers a new niche. Bartenders can experiment with these drinks to create unique cocktails, thus attracting consumers who enjoy both alcoholic and healthy options. Utilizing innovative combinations could redefine contemporary beverage offerings.

5.3 Climate-Resilient Crops

Investments in agricultural research for developing climate-resilient crops can mitigate some sourcing challenges. By working collaboratively with agricultural scientists, beverage companies can help foster varieties of plants that require less water and succeed in harsher climates.

Conclusion

The plant-based beverage industry stands at the crossroads of significant challenges and unprecedented opportunities for innovation. By addressing ingredient sourcing, nutritional challenges, consumer preferences, and regulatory hurdles, companies can pave the way for a sustainable and thriving sector. Through ongoing innovations and a commitment to quality, there remains vast potential for the plant-based beverage market to reshape consumer habits and contribute positively to global health and sustainability goals.

References

Bardasano, J., Calvo, A., & Rivera, M. (2020). Regulatory Challenges in the Plant-Based Beverage Sector. *Journal of Food Regulation*.

de Boer, J., & van der Lans, I. (2021). Consumer Acceptance of Plant-Based Foods: Key Factors. *Trends in Food Science & Technology*.

Duncan, A., Gonzalez, C., & Thomas, E. (2022). Protein Quality of Plant-Based Beverages: An Overview. *Plant Foods for Human Nutrition*.

Godoy, R., Hinojosa, J., & Martinez, J. (2022). Advances in Processing Techniques for Plant-Based Beverages. *Food Science & Technology International*.

Khan, M., Ali, Z., & Elhassan, M. (2023). Fermentation in Plant-Based Beverage Production: A Review. *Journal of Agricultural and Food Chemistry*.

MarketsandMarkets. (2020). Plant-Based Beverages Market - Global Forecast to 2025.

Nielsen. (2022). The Sustainable Packaging Landscape: Trends in Eco-Friendly Packaging Solutions. *Nielsen Insights Report*.

Volume: 04 Issue No: 12

LIFE STYLE CHANGE THROUGH PIG FARMING

Article ID: AG-VO4-I12-130

***R.K. Singh, Dharma Oraon, V.K. Pandey, U.K. Singh, SK Dubey and Zunaid Alam**

Senior Scientist and Head, Scientist (Plant Protection), Scientist (Ag. Engg.) Pro. Asst. Farm Manager, Computer Programmer

Krishi Vigyan Kendra, Chatra

Birsa Agricultural University, Ranchi, Jharkhand-825401, India

*Corresponding Author Email ID: chatrakvk@gmail.com

Introduction

Through Krishi Vigyan Kendra, Chatra, in Jharkhand trained a number of rural unemployed youths for making them successful entrepreneurs, the out come was not so encouraging. However, the situation changed when Shri Prakash Purti, of Bagmari, village under Giddhour block came in contact with KVK, Chatra along with five farm women for training on Improved Pig farming. As all six persons had on an average one acre of land scattered in different locations, they were unable to gain any sustaintial return from agriculture. Finally all of them decided to go for improved Pig farming and for that they approaches the KVK. Their interest in Pig Farming traced back as their traditional occupation, which was familiar to them. But they had left it due to low income or no income from this enterprise, due to poor yielding, Desi breed having slow body growth, less number of piglets and occurrence of diseases.

Training on Improved Pig farming

Keeping all the constraints inconsideration the KVK scientist designed an imparted training improved pig farming during year 2008. After training each person was provided with piglets of tamworth x Desi(T&D) breed (3 female and one male).Later on after six months they were sent for advance training of pig farm of BIrsa Agricultral University , Ranchi. After returning back from the university, they enganged themselves in piggery adopting all scientific practices i.e. feeding disease management and improved Housing. At first[t] harrowing each female pig produced on an average 8 piglets and each family sold 24 pig/2/3 @ Rs. 1200/- per piglet in a year. The economics worked out to be Rs.19,200/ as net profit to per family in the first year in two harrowings.




This success story of pig farming was covered by the local news papers and Shri Praksh Purti and his team became successful pig rearer farmer in the district.

The ATMA identified him as a farmer suitable for running farm a school at his farm. The District Extension Agencies like ATMA, District Animal Husbandry department and LDM also visited his farm and appreciated the efforts made by the KVK and recommended for extrapolation of improved pig farming with T&D breeds with the support of LDM and DDM NABARD about 50 pig farmers have been established in the district by the farmers.

Volume: 04 Issue No: 12

INTEGRATED DISEASE MANAGEMENT OF FUNGAL DISEASES IN RICE

Article ID: AG-V04-I12-131

Dr. T.K.S. Latha*, Dr. N. Indra and Dr. S. Thangeswari
Department of Plant Pathology, Tamil Nadu Agricultural University
Coimbatore – 641 003, Tamil Nadu, India
*Corresponding Author Email ID: latha.tks@tnau.ac.in

Introduction

Besides the abiotic factors *viz*., irrigation water scarcity and insufficient labour force, rice cultivation is greatly affected by biotic factors such as pest and diseases. Though many improved rice varieties have been developed that are showing resistance to major pests and diseases, the resistance is not durable for a long period of time. Hence, it is highly essential to cultivate this crop with existing varieties by adopting suitable integrated disease management strategies.

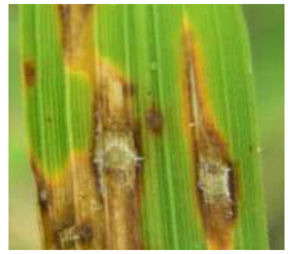
Rice crop is known to be affected by many fungi, bacteria and viral pathogens. Most of the diseases are prevalent in all the rice growing areas and seasons causing severe damage to the crop if no management practice is taken up. The methods for integrated disease management of fungal diseases are discussed in this article.

Blast: P*yricularia oryzae*

Symptoms: The fungus attacks the crop at all stages of crop growth from seedling to late tillering and ear heading stage. Symptoms appear on leaves, nodes, rachis, and glumes. On the leaves, the lesions appear as small bluish green flecks. The lesions soon enlarge under moist weather to form the characteristic spindle shaped spots with grey centre and dark brown margin (Leaf blast). Black lesions appear on nodes girdling them. The affected nodes may break up and all the plant parts above the infected nodes may die (nodal blast). During flower emergence, the fungus attacks the peduncle and the lesion turns to brownish-black which is referred to as rotten neck/neck rot/ panicle blast (neck blast). Small brown to black spots may also be observed on glumes of the heavily infected panicles. The pathogen causes yield losses ranging from 30-61 per cent depending upon the stages of infection.

Rice blast disease- Symptoms

Leaf Blast



Coalesced spots

Nodal Blast

Neck Blast

Favourable conditions: Epidemiology: Intermittent drizzles, cloudy weather, more of rainy high relative humidity (93-99 per cent), low night temperature (between 15-20 C or less than 26 C), availability of collateral hosts and excess dose of nitrogen.

Mode of spread and survival: The disease spreads primarily through airborne conidia since spores of the fungus present throughout the year. Mycelium and conidia in the infected straw and seeds are major sources of inoculum. Irrigation water may carry the conidia to different fields.

Management:

Avoid cultivation of highly susceptible varieties *viz.*, IR50 and TKM6 in disease favourable season.

Remove and destory the weed hosts in the field bunds and channels.

Treat the seeds with Carbendazim or Tricyclazole at 2 g/kg or Bacillus subtilis @ 10g/kg of seed. Spray the nursery with Carbendazim 50 WP 25 g or Edifenphos 50 EC 25 ml for 20 cent nursery. Spray the main field with Edifenphos 500 ml or Carbendazim 250 g or Tricyclazole 75 WP 500 g or Iprobenphos (IBP) 500 ml /ha.

1. ***Brown Spot or Sesame leaf spot:*** **Helminthosporium oryzae**

Symptoms: The fungus attacks the crop from seedling to milky stage in main field. Symptoms appear as minute spots on the coleoptile, leaf blade, leaf sheath, and glume, being most prominent on the leaf blade and glumes. The spots become cylindrical or oval, dark brown with yellow halo. Later becoming tocircular. The several spots coalesce and the leaf dries up..

Favourable Conditions

Temperature of 25-30 C with relative humidity above 80 per cent are highly favourable. Excess of nitrogen aggravates the disease severity.

Mode of Spread and Survival

Infected seeds and stubbles are the most common source of primary infection. Airborne conidia infect the plants both in nursery and in main field. The fungus also survives on collateral hosts like *Leersia hexandra*, and *Echinochlora colonum*.

Management

Field sanitation-removal of collateral hosts and infected debris from the field. Treat the seeds with Thiram or Captan at 4 g/kg. Spray the nursery with Edifenphos 40 ml or Mancozeb 80 g for 20 cent nursery. Spray the crop in the main field with Edifenphos 500 ml or Mancozeb 1 kg when grade reaches 3.

2. **Sheath blight :** *Rhizoctonia solani*

Symptoms:

The fungus affects the crop from tillering to heading stage. Initial symptoms are noticed on leaf sheaths near water level. On the leaf sheath oval or elliptical or irregular greenish grey spots are formed. As the spots enlarge, the centre becomes greyish white with an irregular blackish brown or purple brown border. The presence of several large lesions on a leaf sheath usually causes death of the whole leaf, and in severe cases all the leaves of a plant may be blighted in this way.

The infection extends to the inner sheaths resulting in death of the entire plant.

Sheath blight symptoms



Favourable conditions:

Presence of sclerotia in the soil, Relative humidity from 95 to 100%,Temperature from 28-32 °C, High levels of nitrogen fertilizer, High seeding rate or closing plant spacing

Frequent rain

Mode of Spread and Survival

The pathogen can survive as sclerotia or mycelium in dry soil for about 20 months but for 5-8 months in moist soil. Sclerotia spread through irrigation water. The fungus has a wide host range.

Management

Deep ploughing in summer and burning of stubbles. Spray Carbendazim 250 g /ha. Soil application of *Bacillus subtilis* @ of 2.5 kg/ha after 30 days of transplanting. Foliar spray at 0.2% at boot leaf stage and 10 days later.(1 Kg/ha).

***3. Sheath rot :* Sarocladium oryzae**

Initial symptoms are noticed only on the upper most leaf sheath enclosing young panicles. The flag leaf sheath show oblong or irregular greyish brown spots. They enlarge and develop grey centre and brown margins covering major portions of the leaf sheath. The young panicles may remain within the sheath or emerge partially. The panicles rot and abundant whitish powdery fungal growth is formed inside the leaf sheath.

Favourable Conditions

Closer planting, high doses of nitrogen, high humidity and temperature around 25-30

C. Injuries made by leaf folder, brown plant hopper and mites increase infection.

Mode of Spread and Survival

Mainly through air-borne conidia and also seed-borne.



Sheath rot symptoms

Management

Spray Carbendazim 250g or Edifenphos 500ml or mancozeb 1 kg /ha at boot leaf stage and 15 days later.

4. Grain discolouration

Causal organisms: *Drechslera oryzae, D. rostratum, D.tetramera, Curvularia lunata, Trichoconis padwickii, Sarocladium oryzae, Alternaria tenuis, Fusarium moniliforme, Cladosporium herbarum, Epicoccum purpurascens, Cephalosporium sp., Phoma sp., Nigrospora sp.*


Grain discolouration symptoms

Symptoms

The grains may be infected by various organisms before or after harvesting causing discoloration, the extent of which varies according to season and locality. The infection may be external or internal causing discoloration of the glumes or kernels or both. Dark brown or black spots appear on the grains. The discoloration may be red, yellow, orange, pink or black depending upon the organism involved and the degree of infection. This disease is responsible for quantitative and qualitative losses of grains.

Favourable Conditions:

High humidity and cloudy weather during heading stage.

Mode of Spread and Survival:

The disease spreads mainly through air-borne conidia and the fungus survives as parasite and saprophyte in the infected grains, plant debris and also on other crop debris.

Management:

Pre and post-harvest measures should be taken into account for prevention of grain discolouration. Spray the crop at boot leaf stage and at 50% flowering with Carbendazim + Mancozeb(1:1) @ 0.2%. Store the grains with 13.5-14% moisture content.

5. *False smut:* Ustilaginoidea virens

Symptoms

A sporadic disease. The fungus transforms individual ovaries/grains into greenish spore balls of velvety appearance. Only a few spikelets in a panicle are affected.

Favourable conditions:

Rainfall and cloudy weather during flowering and maturity.

Management:

Preventive measures:

Use of disease-free seeds that are selected from healthy crop. Seed treatment with carbendazim 2.0g/kg of seeds. Control insect pests.Split application of nitrogen is recommended.Removal and proper disposal of infected plant debris.

Cultural methods:

Among the cultural control, destruction of straw and stubble from infected plants is recommended to reduce the disease. Excess application of nitrogenous fertilizer should be avoided.

Chemical methods:

Spraying of copper oxychloride at 2.5 g/litre or Propiconazole at 1.0 ml/litre at boot leaf and milky stages will be more useful to prevent the fungal infection. Seed treatment with carbendazim 2.0g/kg of seeds. At tillering and preflowering stages, spray Hexaconazole @ 1ml/lit or Chlorothalonil 2g/lit.

***6. Udbatta disease:* Ephelis oryzae**

Symptoms

Symptoms appear at the time of panicle emergence The entire ear head is converted into a straight compact cylindrical black spike like structure since the infected panicle
is matted together by the fungal mycelium. The spikelets are cemented to the central rachis and the size is remarkably reduced. The entire spike is covered by greyish stroma with convex pycnidia immersed inside.


Favourable conditions:

- Warm temperature and high humidity
- Early stage of planting from maximum tillering to panicle initiation.

Management

The pathogen is internally seed borne. Hot water seed treatment at 45 C for 10 min. effectively controls the disease. Removal of collateral hosts *Isach neelegans, Eragrostis tenuifolia* and *Cynadon dactylon.*

Volume: 04 Issue No: 12

DISEASE MANAGEMENT IN PROTECTED CULTIVATION

Article ID: AG-VO4-I12-132

***Johnson, I[1]., Karthikeyan, M[1]., Ramjegathesh, R[2]. and Paramasivan, M[3]**
[1]Department of Plant Pathology, TNAU, Coimbatore
[2]NPRC, Vamban, Pudukkottai, [3]RRS, Vriddachalam, Cuddalore, Tamil Nadu, India
*Corresponding Author Email ID: johnson.i@tnau.ac.in

Introduction

Protected farming practices are cropping methods that optimize yield and conserve resources by partially or completely controlling the microenvironment around the plant according to the needs of the plants during their growth cycle. The most practical way to accomplish the goals of protected horticulture is in a greenhouse, where the natural environment is altered using good engineering principles to maximize plant growth and yield (more produce per unit space) while increasing the efficiency of input consumption. In essence, greenhouse buildings are lightweight scaffolding that is coated in plastic, fiberglass, or sheet glass. These materials feature a variety of energy-capturing properties that are all intended to optimize heat retention and light transmission. Using inexpensive plastic greenhouses to grow food offers an alternative to growing crops during a time of scarcity. Along with more effective use of resources, this guarantees a fresh produce supply all year long. To increase profits, the most common vegetable and decorative crops under protected culture are tomatoes, bell peppers, cucumbers, roses, carnations, and gerberas.

Problems in Protected Cultivation

Greenhouses are designed to protect crops from many adverse conditions, but most pathogens are impossible to exclude.

Fungal diseases

Alternaria alternata is found to be a major disease affecting many vegetables and fruits. Capsicum is found to be infected primarily by *Colletotrichum capsici*; *Cercospora capsici* ;

Pythium , *Fusarium*, and *Phytophthora* spp; *Stemphylium solani* and *S. lycopersici* ; *Sclerotium rolfsii* ; *Verticillium albo- atrum* and *V. dahliae* ; *Phytophthora capsici*; *Leveillula taurica* ; and *Botrytis cinerea* causing anthracnose, leaf spot, damping-off, gray leaf spot, stem rot, wilt disease, *Phytophthora* blight, powdery mildew, and gray mold, respectively.

Cucumber and other vegetables attract a considerable quantum of fungal pathogens. Out of which downy mildew (*Pseudoperonospora cubensis*), powdery mildew (*Erysiphe cichoracearum* and *Sphacelotheca fuliginea*), *Alternaria* leaf spot (*Alternaria cucumerina*), anthracnose (*Colletotrichum lagenarium*), damping-off (*Pythium* spp) and rust diseases (*Puccinia* spp. *Uromyces* spp. and *Phragmidium* spp.) are important. Survival of pathogen is also enhanced inside the poly-house due to availability of host because of longer growing season.

Bacterial diseases

Bacterial diseases are less frequent but under high moisture and poor irrigated conditions may cause huge damage. *Erwinia carotovora* s.sp. *carotovora* (bacterial soft rot), *Xanthomonas campestris* pv *vesicatoria* (bacterial spot), *Ralstonia solanacearum* (bacterial wilt), *Pseudomonas syringae* pv *lachrymans* (angular leaf spot), *Erwinia chrysanthemi* and *Erwinia tracheiphila* are pronounced to name some.

Viral Diseases

The symptoms of viral infections are often not found everywhere in a cultivated field but rather in patches and also sometimes without symptoms. Viruses prevalent among greenhouse crops include tobacco mosaic virus or tomato mosaic virus (TMV or ToMV), cucumber mosaic virus (CMV), tobacco etch virus (TEV), potato virus-Y (PVY), potato leaf roll virus (PLRV), tomato spotted wilt virus (TSWV), alfalfa mosaic virus, pepper veinal mottle virus (PVMV), pepper mild mottle virus (PMMY), chili veinal mottle virus (CVMV Or ChiVMV), tomato yellow leaf curl virus (TYLCV), and tomato big-bud mycoplasma (TBB). Most viruses are spread by insect vectors, such as whitefly, aphid, and thrips; others are seed borne and mechanically transmitted.

Disease management strategies

Host-Plant resistance to pathogens

Host plant resistance includes morphological constitutive defence mechanisms which are the waxes of the cuticle that form a hydrophobic surface preventing water retention and pathogen deposition, germination and penetration. Lignification or suberization gives additional effective protection. The size and distribution of stomata and lenticels are associated with resistance to those insects, bacteria and fungi that make their entries through these structures. There are also internal secretions of inhibitors like phenolic acids in coloured onions and tomatine in tomato.

Role of soil fumigation in protected cultivation

Soil fumigants are applied to the soil as a liquid, volatile gas, or granule. The fumigant must be incorporated into the soil immediately after application because of its high volatility.

Methyl bromide : Effective against many soilborne fungi (e.g.) *Rhizoctonia* spp., *Pythium* spp., *Phytophthora* spp., *Sclerotinia sclerotiorum*, *Sclerotium rolfsii, Verticillium* spp. and *Fusarium* spp.)

3,5, dimethyl-tetrahydro-l,3,5,(2H) thiodiazino-thione: *Verticillium dahliae*, *Verticilium albo-atrum*, *Rhizoctonia solani, S. sclerotiorum, Phytophthora* spp. and *Pythium* spp.

Metham sodium (sodium methyldithiocarbamate) (MES): Pythiaceous fungi, races of *Fusarium oxysporum, S. sclerotiorum, S. rolfsii, V. dahliae* and species of *Phoma, Botrytis,* etc.

Soil fumigants are toxic to plants and can also be harmful to human health and the environment. The EPA has implemented safety measures to protect agricultural workers and by standers.

Fungicides/Chemical in disease management

Selected fungicides and their efficacy in disease management in particular crops under protected cultivation are listed below

Fungicide	Disease
Copper sulphate	Angular leaf spot, downy mildew, Alternaria blight, anthracnose, bacterial blight diseases on Cucumber, Eggplant, Pepper, tomato
Copper hydroxide	Leaf spots, anthracnose, bacterial spots, and other diseases on many vegetables
Copper salts of fatty and rosin acids	Bacterial leaf spots, leaf spots and blights, downy and powdery mildew diseases of Greenhouse vegetables
Cuprous oxide	Anthracnose, *Phomopsis*, *Botrytis* , leaf spots and blights of Tomato, pepper, eggplant
Dichloran	*Botrytis* , white mold (*Sclerotinia*) diseases of Cucumber,

	leaf lettuce, tomato
Fenhexamid	*Botrytis* infection on Fruiting vegetables, tomatoes, cucumber, leafy greens
triadimefon, fenarimol, ethirimol and dinocap	Powdery mildews in Cucurbit, solanaceous and many floral crops
Ziram, zineb, maneb, mancozeb, chlorothalonil and metalaxyl	Damping off by *Pythium*, *Phytophthora* blight on many vegetables
Ziram, maneb, mancozeb, chlorotholonil, iprodione	Alternaria blight on many vegetables
zineb, maneb, mancozeb, chlorothalonil, or oxycarboxin, Hexaconazole, propiconazole, and tebuconazole.	Rust diseases of many floral and vegetable crops

Biological management of diseases under protected cultivation

Several formulations of either of the fungi *Gliocladium* and *Trichoderma* or the bacteria *Pseudomonas* and *Bacillus* have been widely used for biocontrol of soilborne pathogens. These products are not only registered as biofungicides but also used as plant strengtheners. In many countries, plant strengtheners include inorganic compounds such as SiO_2, $NaHCO_3$, organic constituents such as compost, homeopathic compounds, and some containing microorganisms such as *Trichoderma harzianum* , *Bacillus subtilis*, *Pseudomonas*, and *Pythium oligandrum.*

For successful management of greenhouse pests can be done by using integrated approach. It is important for greenhouse producers in India to implement as many IPM exclusion strategies as possible to manage insect-pests. Therefore, excluding the pests from entering the greenhouse is of utmost importance. Integrated approaches involving bio control agents, botanicals and microbial pathogen with limited and ecologically safe insecticides to non-target organisms must be developed and adopted at large scale.

Volume: 04 Issue No: 12

GUARDING YOUR CARNATIONS: KEY STRATEGIES FOR DISEASE PREVENTION AND MANAGEMENT

Article ID: AG-VO4-I12-133

***M. Karthikeyan, I. Johnson, M. Paramasivan**

Department of Plant Pathology, Centre for Plant Protection Studies,

Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India

*Corresponding Author Email ID: karthikeyan.m@tnau.ac.in

Introduction

Floriculture, an emerging and vibrant sector, has experienced rapid growth across the globe, particularly in India, where the floriculture industry has gained considerable momentum. As of 2007, India's area under traditional flower cultivation was 73,536 hectares, with over 1000 hectares now cultivated under protected conditions. With an annual production of 3,65,668 metric tonnes, the country has seen a significant increase in floriculture activities, especially in states like Karnataka (20,780 ha), Tamil Nadu (17,750 ha), and West Bengal (13,750 ha). According to Patil et al. (2004), the national income generated from floriculture, including both traditional and modern cut flowers, is approximately Rs.500 crores annually.

Floriculture's global trade in cut flowers is valued at 40 billion US dollars, with the Indian floriculture industry growing at a compounded annual growth rate (CAGR) of 25% over the past decade. The flower export market is projected to reach 20 billion US dollars by 2020 (Gian Aggarwal, 2011). As the awareness of cut flowers for various occasions increases, demand has surged, spurring growth in both domestic and export markets. Consequently, flower production in India has expanded from 2,071 million stems in 2007 to 6,667 million stems by 2011, reflecting a rise in the quality of life and standard of living of consumers. Among the most valued flowers in the cut flower industry is the carnation (Dianthus caryophyllus L.), commonly referred to as the "Divine Flower." Originating from the Mediterranean region, carnation is a member of the Caryophyllaceae family. In India, it is an introduced crop that thrives in regions with mild climates, such as Nilgiris, Kodaikanal, Bangalore, Pune, and Shimla. Particularly in Tamil Nadu, the regions of Nilgiris, Yercaud, and Kodaikanal provide optimal conditions for the cultivation of carnation alongside other high-value flowers like chrysanthemum, lily, gerbera, and anthurium.

The economic significance of carnation cultivation is substantial, offering substantial remuneration to growers. As a cut flower, carnation holds a prestigious place in the global floriculture trade and is increasingly popular among flower growers and traders. Given India's diverse climatic conditions and the favorable environment of Tamil Nadu, the country has immense potential for cultivating high-quality carnations. The conducive weather in areas such as Kodaikanal and Nilgiris makes Tamil Nadu a major player in the floriculture business.

However, despite its profitability, the cultivation of carnation faces challenges, primarily due to disease issues. The continuous cultivation of carnations under protected conditions, coupled with intensive monoculture practices and indiscriminate pesticide use, makes the crop highly susceptible to diseases. Notably, Fusarium wilt, caused by *Fusarium oxysporum* f.sp. *dianthi*, is one of the most significant pathogens affecting carnation production. The intensive nature of carnation cultivation, with minimal crop rotation, leads to soil depletion and a higher vulnerability to soil-borne and foliar diseases.

The diseases affecting carnations are varied and pose substantial threats to both the quality and quantity of the flowers produced. These include:

Fungal Diseases

1. **Stem and Root Rot** – *Phytophthora nicotianae var. parasitica*, *P. capsici*, *P. cryptogea*
2. **Sclerotinia Stem Rot** – *Sclerotinia sclerotiorum*
3. **Collar Rot / Stem Rot / Root Rot** – *Rhizoctonia solani*, *Thanatephorus cucumeris*
4. **Fusarium Stub Dieback / Basal Rot** – *Fusarium roseum*, *F. avenacearum*, *F. culmorum*, *F. graminearum*
5. **Sclerotium Root Rot / Basal Rot** – *Sclerotium rolfsii*, *Athelia rolfsii*
6. **Pythium Root Rot / Foot Rot** – *Pythium vexans*, *P. irregulare*, *P. aphanidermatum*
7. **Wilt** – *Fusarium oxysporum* f.sp. *dianthi*
8. **Alternaria Leaf Spot / Blight** – *Alternaria dianthi*, *A. dianthicola*
9. **Fairy Ring Leaf Spot** – *Cladosporium echinulatum*, *Mycospharella dianthi*
10. **Rust** – *Uromyces dianthi*
11. **Grey Mold** – *Botrytis cinerea*

Bacterial Diseases

1. **Bacterial Wilt** – *Burkholderia caryophylli*, *Pseudomonas caryophylli*, *Erwinia chrysanthemi* pv. *dianthicola*
2. **Bacterial Leaf Spot** – *Burkholderia* spp., *Pseudomonas andropogonis*

Viral Diseases

1. **Carnation Virus Complex** – Includes *Carnation Mottle Virus* (Carmovirus), *Carnation Vein Mottle Virus* (Potyvirus), *Carnation Ring Spot Virus* (Dianthovirus), *Carnation Etched Ring Virus* (Cauliovirus), *Carnation Latent Virus* (Carla virus), and *Carnation Necrotic Fleck Virus*.

Nematodes and Abiotic Disorders

- Root Knot Nematode – *Meloidogyne incognita*

The damage caused by these diseases can lead to substantial yield losses, diminishing the quality of the blooms and reducing the marketability of the flowers. Addressing these diseases through Integrated Disease Management (IDM) strategies is essential to ensuring the sustainability and profitability of carnation cultivation. Effective management practices are needed to combat these pathogens and ensure healthy growth, high-quality blooms, and sustained yield for flower producers in Tamil Nadu and other key floriculture regions.

1.0 Fungal Diseases of Carnations

1.1. Stem and Root Rots

Causal Organism: The main causative agent of stem and root rot in carnations is *Phytophthora nicotianae var. parasitica* (Breda de Haan var. parasitica (Dastur) Waterhouse), although *P. capsici* and *P. cryptogea* are also associated with the disease. These pathogens infect carnations and other plants, particularly under favorable environmental conditions.

Diagnostic Symptoms: Plants affected by stem and root rot exhibit wilting. A close examination of infected plants reveals brown discoloration at the collar region, which eventually leads to plant death. The symptoms are characterized by the softening and rot of the roots and stems. The pathogen thrives at temperatures between 10°C and 35°C, with an optimum temperature of 27°C for growth. However, the disease develops more rapidly at temperatures ranging from 5°C to 35°C than at 15°C-20°C.

Survival and Spread: *Phytophthora* pathogens survive in soil and plant debris and spread through contaminated water and farm tools. The disease thrives in moist, cool environments, and its spread is facilitated by irrigation practices and contact with infected plants. The pathogens can also persist in crop residues, making it difficult to manage once established in the soil.

Disease Management:

- **Biological Control:** Soil drenching with biocontrol agents like *Bacillus subtilis*, *B. amyloliquefaciens*, and *B. cereus* helps control the spread of the disease. These agents compete with the pathogen and prevent its establishment in the soil.
- **Chemical Control:** Fungicides like *carbendazim* and *metalaxyl* can also be used effectively to reduce disease incidence, particularly when applied in combination with biocontrol agents.

1.2. Sclerotinia Stem Rot

Causal Organism: The disease is caused by *Sclerotinia sclerotiorum*, a highly destructive pathogen affecting carnations.

Diagnostic Symptoms: Sclerotinia stem rot causes gradual wilting of affected plants, which is unlike Fusarium wilt, as the wilting is not limited to one side. The leaves turn straw-colored, and the stems become hollow. Upon examining the longitudinal section of the infected stem, irregular brown-colored sclerotia (fungal resting bodies) are observed. The vascular system of the stem also turns brown.

Survival and Spread: The pathogen survives as sclerotia in the soil and in infected plant tissues. It can also spread through infected plant debris. The disease thrives in cool, moist soil, and alternate crops like beans can act as reservoirs for the pathogen.

Disease Management:

- **Biological Control:** Soil drenching with *Bacillus amyloliquefaciens* (VB7) and *Trichoderma asperellum* (NVTA2) significantly reduces the incidence of stem rot by antagonizing the pathogen and promoting the growth of beneficial microorganisms.
- **Chemical Control:** Fungicides such as *axoxystrobin*, *tebuconazole* + *trifloxystrobin*, and *carbendazim* are effective in managing the disease.

1.3. Collar Rot / Stem Rot / Root Rot

Causal Organism: *Rhizoctonia solani* Kuhn, also known as *Thanatephorus cucumeris* (Frank) Donk, is the causal organism responsible for collar rot, stem rot, and root rot.

Diagnostic Symptoms: Infected plants display stunted growth, and lesions develop on the stem near or below the soil level. The lesions result in the weakening and breakage of the stem, causing wilting and death of the entire plant. The disease is more severe under dry and humid weather conditions, with a temperature range of 5°C to 30°C favoring the spread.

Survival and Spread: *Rhizoctonia solani* is soil-borne and spreads through farm tools and irrigation water. The pathogen persists in soil and infects plants during moist conditions.

Disease Management:

- **Biological Control:** Using biocontrol agents like *Pseudomonas fluorescens*, *Bacillus subtilis*, and *B. amyloliquefaciens* in seedling dips and soil applications can effectively suppress the pathogen.
- **Chemical Control:** Soil drenching with fungicides like *difenoconazole*, *carbendazim*, or *azoxystrobin* at regular intervals is recommended to manage the disease.

1.4. Fusarium Stub Dieback / Fusarium Basal Rot

Causal Organism: The pathogens involved in this disease are *Fusarium roseum*, *Fusarium avenaceum*, *F. culmorum*, and *F. graminearum*.

Diagnostic Symptoms: This disease affects carnation plants after harvesting or pinching of shoots. The pathogens attack the mature plant stubs and main stems, causing girdling and wilting of branches. The vascular tissues do not discolor but the stems break down, leading to plant death. Dieback may occur in the upper parts of the plant as well.

Survival and Spread: The disease is spread by injuries caused during continuous harvesting of cuttings. The pathogens survive on infected plant debris and are spread through the release of ascospores from perithecia. Humid and warm conditions with high nitrogen fertilization favor disease development.

Disease Management:

- **Cultural Practices:** Use disease-free cuttings and ensure proper maintenance of the rooting medium.
- **Chemical Control:** Drenching of the rooting medium with *thiophanate-methyl* (0.1%) or *carbendazim* (0.1%) is effective for managing this disease.
- **Biological Control:** Soil application of *Pseudomonas fluorescens*, *B. subtilis*, and *B. amyloliquefaciens* helps suppress the disease.

1.5. Sclerotium Root Rot / Basal Rot

Causal Organism: *Sclerotium rolfsii* Sacc., also known as *Athelia rolfsii* (Curzi) Tu & Kimbrough, causes this disease.

Diagnostic Symptoms: Infected plants exhibit pale green leaves that eventually dry up. The stems and roots rot, leading to the death of the plant. White, cottony mycelium is visible at the collar region, and in advanced stages, spherical sclerotial bodies are found on the stem at the soil level.

Survival and Spread: The pathogen survives in the soil as sclerotia and spreads through alternating wet and dry soil conditions. It also survives on crop residues, making it difficult to control once established.

Disease Management:

- **Biological Control:** Seedling dips in biocontrol agents like *Pseudomonas fluorescens*, *B. subtilis*, or *B. amyloliquefaciens* and soil application of these agents at a rate of 2.5 kg/ha mixed with compost or FYM help control the disease.
- **Chemical Control:** Soil drenching with *difenoconazole*, *carbendazim*, or *azoxystrobin* can reduce disease spread and severity.

1.6 Pythium Root Rot / Foot Rot

Causal Organisms:

- *Pythium vexans* de Bary
- *Pythium irregulare*
- *Pythium aphanidermatum* (Edson) Fitzp.

Symptoms: Pythium root rot typically affects the collar region of the carnation plant, causing a gradual discoloration followed by drying of the leaves, starting from the bottom and progressing upward. The infection leads to the rotting of the stem at soil level, eventually causing the plant's death. The disease is more pronounced in conditions of high soil moisture and increased humidity, especially when crop residues are present.

Survival and Spread: The pathogen survives in the soil and in infected plant debris. It primarily spreads through irrigation water, where spores can move and infect new plants.

Disease Management:

- Soil drenching with fungicides such as azoxystrobin (0.15%) or difenaconazole (0.05%) effectively suppresses the disease.
- Biological control using *Trichoderma viride* (2.5 kg/ha in 250 kg compost) has also been proven to help in disease suppression.

1.7 Wilt (Fusarium Wilt)

Causal Organism: *Fusarium oxysporum* f. sp. *dianthi*

Symptoms: Carnation wilt caused by *Fusarium oxysporum* results in the yellowing of leaves, particularly at the basal portions, and wilting. Infected leaves exhibit chlorosis and ultimately wilt. The disease begins on one side of the plant, causing the affected stems to shrivel and leading to the gradual wilting of the entire plant. Vascular browning of stems is often observed. The disease affects both seedlings and older plants, with symptoms progressing from the lower leaves to the entire plant.

Spread and Survival: *Fusarium oxysporum* f. sp. *dianthi* is highly diverse and can exist in different races that affect various carnation cultivars. The pathogen spreads via infected cuttings, soil, and water. It thrives in acidic soils with a pH of around 6.0 and temperatures between 25-30°C.

Disease Management:

- Drenching the roots with difenoconazole or azoxystrobin (2 ml/liter) helps control wilt.
- Biological control agents such as *Bacillus subtilis*, *Bacillus amyloliquefaciens*, *Bacillus cereus*, *Pseudomonas aeruginosa*, and *Trichoderma viride* have been found effective in suppressing the disease and enhancing plant growth.

1.8 Alternaria Leaf Spot / Blight

Causal Organisms:

- *Alternaria dianthi* Stevens & Hall
- *Alternaria dianthicola* Neergaard

Symptoms: The initial symptoms appear as small purple lesions on the lower leaf surface, which later turn into grayish-brown spots. In favorable conditions, these lesions enlarge and coalesce, leading to leaf blighting. The disease can also spread from the leaves to the stems, causing girdling and further weakening the plant.

Spread and Survival: The pathogen survives on infected plant debris, and infection requires at least 8 to 10 hours of moist conditions. The disease spreads through airborne spores.

Disease Management:

- Ensure good air circulation and low humidity to reduce disease severity.
- Foliar applications of fungicides like iprodione, difenaconazole, mancozeb, azoxystrobin, or chlorothalonil are effective in controlling the disease.

1.9 Fairy Ring Leaf Spot

Causal Organism:

- *Cladosporium echinulatum* (Berk.) De Vries
- *Mycospharella dianthi* (Burt) Jorst.

Symptoms: The disease is characterized by pinhead-sized tan spots on the leaf and leaf sheath, with purple to dark purple margins. These spots may enlarge into circular to oval shapes with a gray center. In severe cases, lesions coalesce, leading to blighted leaves that dry and defoliate. The disease can also spread to petals, causing oval-shaped tan spots with black fruiting bodies.

Survival and Spread: The pathogen survives on infected plants and debris. Wet weather, high humidity, and moisture on the leaves favor the spread of the disease.

Disease Management:

- Good air circulation and reduced humidity help mitigate the disease.
- Fungicides like difenaconazole, azoxystrobin, propiconazole, mancozeb, or iprovalicarp reduce disease severity.

1.10 Rust

Causal Organism: *Uromyces dianthi* (Pers.) Niessl

Symptoms: Rust appears as light green lesions on the leaves, which later develop into small brown pustules containing a powdery mass of brown spores. As the infection progresses, the lesions can spread to the stems, leading to plant withering and reduced flower quality. In severe cases, rust causes the drying of leaves and stems, affecting both growth and yield.

Spread and Survival: Rust is an airborne disease, and the urediniospores remain viable for up to six months. The disease thrives in areas with high precipitation and low temperatures, favoring high humidity.

Disease Management:

- Foliar application of fungicides such as myclobutanil, tebuconazole, mancozeb, or azoxystrobin can control rust.
- The cultivation of resistant cultivars also helps in reducing the disease incidence.

1.11 Grey Mould

Causal Organism: *Botrytis cinerea*

Symptoms and Disease Management: Grey mould primarily affects flowers and stems, causing soft rot, wilting, and the formation of grayish, fuzzy mold on infected tissues. This disease thrives in environments with high humidity. Disease management involves maintaining dry conditions, improving air circulation, and applying fungicides like iprodione, fenhexamid, or tebuconazole.

2.0 Bacterial Diseases of Carnations

2.1 Bacterial Wilt

Causal Organism: The bacteria responsible for bacterial wilt in carnations are *Burkholderia caryophylli* (Burkholder) Yabuuchi, also known as *Pseudomonas caryophylli* (Burkholder) Starr & Burkholder, and *Erwinia chrysanthemi* pv. *dianthicola* (Burkholder et al.).

Symptoms: Infected carnations show characteristic symptoms such as greyish-green foliage, which gradually wilts and dies. The roots of affected plants rot, emitting a foul odor. The vascular tissues exhibit yellowing to browning, and the basal portion of the stem may crack. Infections caused by *E. chrysanthemi* pv. *dianthicola* result in slow wilting, stunted plant growth, and reduced root systems. The vascular bundles become brown, and the basal part of the stem necrotizes, leading to plant death.

Spread and Survival: The pathogen is primarily soil-borne and spreads through contaminated farm equipment during field operations, including weeding, pruning, and other intercultural activities. It can also spread via irrigation water and infected plant debris.

Disease Management: The primary control measure includes maintaining proper sanitation by removing infected plants and plant debris. Foliar applications of bacterial antibiotics like streptomycin sulfate (250 ppm) combined with copper fungicides (0.25%) have been effective in controlling the disease.

2.2 Bacterial Leaf Spot/Blight

Causal Organism: The causative agents of bacterial leaf spot and blight are *Burkholderia andropogonis* (Smith) Gillis, *Pseudomonas andropogonis* (Smith) Stapp, and *P. woodsii* (Smith) Stevens.

Symptoms: The disease begins with small, water-soaked yellow specks on the leaves. Over time, these spots coalesce, leading to extensive blighting, particularly during severe infections. The extent of the disease spread can vary depending on climatic factors such as temperature and rainfall. The disease can spread slowly around the edges of leaves, rapidly across large areas, or decline vertically from top to bottom.

Spread and Survival: Like bacterial wilt, the pathogen is soil-borne and spreads through farm tools, irrigation water, and plant debris during field operations.

Disease Management: Effective control measures include proper sanitation practices, such as removing infected plants and plant debris. Application of bacterial antibiotics like streptomycin sulfate (250 ppm) and copper fungicides (0.25%) can help reduce disease severity.

3.0 Viral Diseases of Carnations

Carnations are susceptible to several viral diseases, including:

- **Carnation Mottle Virus (CarMV)** (genus Carmovirus)
- **Carnation Vein Mottle Virus (CaVMV)** (genus Potyvirus)
- **Carnation Ring Spot Virus (CaRSV)** (genus Dianthovirus)
- **Carnation Etched Ring Virus (CaERV)** (genus Cauliovirus)
- **Carnation Latent Virus (CaLV)** (genus Carlavirus)
- **Carnation Necrotic Fleck Virus (CaNFV)** (genus Closterovirus)

Symptoms: These viruses cause various mosaic symptoms, including mottling, chlorotic mottle, green vein mottle, necrotic flecks, rings, etched patterns, and whitish or necrotic streaks. Viral infections often manifest as distinct leaf and stem abnormalities, and infected plants may exhibit stunted growth. The transmission of these viruses occurs primarily through mechanical means (sap) or via aphids, particularly *Myzus persicae*.

4.0 Integrated Disease Management (IDM) for Carnation

Integrated Disease Management (IDM) in carnation aims to reduce the incidence of plant diseases through a combination of cultural, physical, biological, chemical, and regulatory measures. The following strategies are crucial for an effective IDM approach:

4.1 Cultural Practices

- **Crop Sanitation**: Removing infected plant material and debris is essential in preventing disease spread. Infected carnation plants, including those affected by Fusarium wilt, rust, and bacterial wilt, should be destroyed immediately. Cleaning tools and equipment used in field operations will help reduce pathogen transmission.
- **Soil Solarization**: This method involves covering the soil with transparent plastic for a period of seven weeks, which increases the soil temperature and effectively reduces the inoculum load of soil-borne pathogens like *Fusarium oxysporum* f.sp. *dianthi* and *Pythium* species. This practice has proven beneficial in reducing the incidence of root rot and wilt diseases.

- **Weed Management**: Weeds should be controlled to prevent them from serving as reservoirs for pathogens, particularly those involved in leaf spots and rusts. Regular weeding also improves air circulation and reduces humidity, further preventing the conditions for foliar diseases.

4.2 Crop Rotation

Crop rotation can help reduce the inoculum density of soil-borne pathogens, as most of these pathogens have a wide host range. However, careful selection of rotation crops is necessary since some pathogens, like *P. nicotianae* and *P. cryptogea*, can also infect other crops. Non-host crops should be chosen to break the disease cycle effectively.

4.3 Adjustment of Planting Dates

Adjusting the planting time can help reduce the risk of disease outbreaks, especially when the crop is less susceptible to specific pathogens during certain growth stages. This is particularly effective for managing foliar diseases like *Alternaria* leaf spot and *Rust*, as altering the planting time can reduce the overlap between the plant's susceptibility and pathogen presence.

4.4 Nutrient Management

Maintaining proper soil nutrition plays a vital role in enhancing plant health and disease resistance. Nitrogen levels should be carefully managed to avoid excessive lush growth, which predisposes plants to disease. Organic amendments like compost or vermicompost can help improve soil health, suppress soil-borne pathogens, and reduce the spread of *Fusarium* wilt.

4.5 Physical and Mechanical Methods

- **Improved Air Circulation**: Enhancing air circulation in polyhouses reduces humidity and leaf moisture, preventing the conditions that favor foliar diseases like rust and leaf spots.
- **Physical Barriers**: In polyhouses, the use of insect-proof nets can reduce the spread of viral and bacterial diseases transmitted by insects, particularly aphids.

4.6 Biological Control

Biological control agents (BCAs) can be introduced into the system to control specific pathogens. For example, Trichoderma spp. and Bacillus spp. are known to suppress *Fusarium* wilt and other root pathogens. These BCAs can be applied as soil drenches or incorporated into the growing medium to help control soil-borne diseases.

4.7 Chemical Control

Chemical control, although used in conjunction with other IDM strategies, remains a key component for managing diseases in carnation. Fungicides like strobilurins (e.g., azoxystrobin) and systemic fungicides (e.g., difenoconazole) are effective against various foliar and soil-borne pathogens. Antibiotics like streptomycin sulphate are useful in controlling bacterial diseases like bacterial wilt and leaf spot.

4.8 Regulatory Measures

Quarantine measures are critical to prevent the introduction of new pathogens, particularly those from imported planting materials. Importation of disease-free cuttings and adherence to post-entry quarantine protocols will help in managing the spread of diseases like crown gall and Fusarium wilt. Stringent monitoring systems should be implemented to detect the early presence of new pathogens.

Conclusion

Effective disease management in carnation requires a multifaceted approach that combines cultural, physical, biological, chemical, and regulatory strategies. By integrating these methods, growers can reduce the impact of both fungal and bacterial diseases while maintaining healthy and high-yielding carnation crops. Regular monitoring, adherence to good agricultural practices, and timely interventions are key to preventing disease outbreaks. The integration of these measures not only helps in managing existing diseases but also in reducing the risk of future disease epidemics. With the right combination of techniques, carnation growers can safeguard their crops against the diverse range of diseases, ensuring both plant health and economic sustainability.

Volume: 04 Issue No: 12

FUSARIUM INFECTION - AN EMERGING CHALLENGE IN MILLETS

Article ID: AG-VO4-I12-134

***Johnson, I[1]., Yuvashree, B[1]., Karthikeyan, M[1] and Paramasivan, M[2]**

[1]Department of Plant Pathology, TNAU, Coimbatore, Tamil Nadu, India

[2]Regional Research Station, Vriddachalam, Cuddalore, Tamil Nadu, India

*Corresponding Author Email ID: johnson.i@tnau.ac.in

Introduction

Millets are staple crops in semi-arid and arid regions of South Asia and sub-Saharan Africa. Known for their drought tolerance and ability to grow in poor soils, millets thrive in challenging environments, making them crucial for food and fodder in these regions. Despite their resilience to environmental stresses like heat and drought, millets face significant threats from diseases caused by harmful microorganisms, including *Fusarium species*, which impact their productivity.

Fusarium species are highly adaptable pathogens that infect many plants across diverse environments. These fungi cause diseases like wilt, root rot, and stem rot and produce toxic secondary metabolites (e.g., fumonisins, trichothecenes) that harm plants, animals, and humans. *Fusarium infections* disrupt water and nutrient transport by colonizing xylem tissues, leading to yield losses in crops like wheat, rice, sugarcane, and bananas, posing a threat to food security.

Major *Fusarial* diseases:

- ***Fusarium* Wilt**: Caused by the *Fusarium oxysporum species complex*, this disease affects a wide range of crops, including bananas, tomatoes, and legumes. It infects roots and colonizes xylem vessels, causing wilting, yellowing, and vascular discoloration. The pathogen thrives in warm, moist soils and persists as chlamydospores or plant debris.
- **Root and Crown Rot**: Caused by *F. solani* and *F. oxysporum*, this disease affects roots and stem bases, leading to rotting, wilting, and stunted growth. Severe infections can cause plant death. Wet, poorly drained soils and high humidity favour the disease

- **Pokkah Boeng**: Caused by *F. moniliforme* (*F. verticillioides*), this disease distorts shoots and stunts growth. Symptoms include yellowing, wilting, and top shoot death, with severe cases leading to plant death and significant yield loss.

Fusarium infections on millets

Millets, vital cereal crops cultivated predominantly in dryland regions, are known for their nutritional benefits and resilience to harsh climatic conditions. However, despite their significance, research on *Fusarium* infections in millets has been relatively limited. *Fusarium* species are among the most impactful fungal pathogens affecting millet crops, causing significant yield losses, grain quality deterioration, and food safety concerns due to mycotoxin contamination.

Distribution and impact of _Fusarium_ species on millets

Several *Fusarium* species are associated with millets and other crops, with their distribution and impacts varying across regions. *Fusarium equiseti* was reported on millet in Lesotho for the first time, although it is widely distributed in temperate and tropical regions globally. *F. nygamai*, found in Australia, South Africa, Thailand, Puerto Rico, Nigeria, and Namibia, infects millet. *F. moniliforme*, a globally prevalent pathogen, infects corn, millet, sorghum, and sugarcane, posing a major threat to corn production worldwide. *F. semitectum*, common in tropical regions, occurs as a saprophyte in soil and decaying plant material, while *F. napiforme*, initially reported on millet and sorghum in southern Africa and Australia, requires further study to determine its impact on millet.

Notably, studies from Lesotho revealed that only *F. equiseti* was isolated from millet, while cosmopolitan species like *F. moniliforme* and *F. semitectum* were absent, possibly due to the region's cooler climate or limited sampling. Furthermore, morphological variations in *F. nygamai* and its relationship with *F. moniliforme* highlight the need for further investigation.

Fusarium Infections in Specific Millets

Proso Millet

Proso millet (*Panicum miliaceum*) is susceptible to *Fusarium* species such as *F. asiaticum*, *F. acuminatum*, *F. graminearum*, *F. incarnatum*, *F. equiseti*, and *F. tricinctum*. These pathogens produce mycotoxins like nivalenol (NIV) and T-2/HT-2 toxins, posing serious health risks. Fusarium infections reduce grain quality, lead to mycotoxin contamination, and significantly challenge food safety and marketability.

Pearl Millet

Pearl millet (*Pennisetum glaucum*) is vulnerable to infections by *F. graminearum* and *F. culmorum*, which cause reductions in grain weight and nutritional content, including a 10% decrease in β-glucan levels. Post-harvest losses are substantial, reaching up to 15% globally, with higher rates in developing countries. Additionally, a newly emerged disease, sheath and stem blight, was reported in Tamil Nadu, India, with a disease index of 25–30%. This disease, resembling Pokkah Boeng, progresses differently, underscoring the evolving nature of *Fusarium*-related diseases.

Finger Millet

Finger millet (*Eleusine coracana*) is primarily affected by *Fusarium* species within the *F. incarnatum–equiseti species complex* (FIESC). A newly identified toxigenic species within this complex accounts for 33% of isolates, posing risks of mycotoxin contamination. These infections reduce grain yield and compromise food safety, highlighting the urgent need for further research.

Foxtail Millet

Foxtail millet (*Setaria italica*), the second-most widely cultivated millet, is highly susceptible to *Fusarium*-induced grain mold and stalk rot, particularly in regions like Iran. These infections lead to significant production losses and introduce harmful mycotoxins. Wilt and root rot, primarily caused by *F. nygamai*, are prevalent, with field incidence rates ranging from 25% to 75%. Infected plants exhibit symptoms such as yellowing, stunting, poorly developed roots, and straw-colored lower stalks that soften with gray-white mold at stem nodes, severely affecting plant health and yield.

Implications and Future Directions

Fusarium infections in millets pose significant economic and health challenges, particularly in developing regions where millets are staple crops. The presence of mycotoxins further exacerbates these challenges, threatening human and animal health. The emergence of new diseases, such as sheath and stem blight in pearl millet, underscores the dynamic and evolving nature of *Fusarium* infections.

To address these challenges, a multifaceted approach is required. This includes:

- Enhanced research on *Fusarium* species affecting millets and their associated mycotoxins.
- Comprehensive studies on emerging *Fusarium* species and their pathogenicity.

- Development of effective management strategies to mitigate yield losses and ensure food safety.
- By prioritizing these areas, we can protect millet crops, safeguard food security, and reduce the health risks associated with *Fusarium* infections in millets.

References

Akanmu, A. O., Abiala, M. A., & Odebode, A. C. (2013). Pathogenic effect of soilborne *Fusarium* species on the growth of millet seedlings. *World Journal of Agricultural Sciences*, *9*(1), 60-68.

Bouajila, A., Lamine, M., Rahali, F., Melki, I., Prakash, G., & Ghorbel, A. (2020). Pearl millet populations characterized by *Fusarium* prevalence, morphological traits, phenolic content, and antioxidant potential. *Journal of the Science of Food and Agriculture*, *100*(11), 4172-4181, https://doi.org/10.1002/jsfa.10456

Chala, A., Degefu, T., & Brurberg, M. B. (2019). Phylogenetically diverse *Fusarium* species associated with sorghum (*Sorghum bicolor* L. Moench) and finger millet (*Eleusine coracana* L. Garten) grains from Ethiopia. *Diversity*, *11*(6), 93.

Choi, J. H., Nah, J. Y., Lee, M. J., Jang, J. Y., Lee, T., & Kim, J. (2021). *Fusarium diversity and mycotoxin occurrence in proso millet in Korea. LWT, 141, 110964*, https://www.sciencedirect.com/science/article/pii/S0023643821001171

Fard, M. B., Mohammadi, A. B. B. A. S., & Darvishnia, M. O. S. T. A. F. A. (2014). *Fusarium* species associated with foxtail millet (*Setaria Italica*) in Iran.

Naorem, M. Saritha, S. Kumar, N.R. Panwar, K.K. Meena, A. Patel, K. Doodhawal, T. Jaajpera, B. Ram, Pearl Millet (*Pennisetum glaucum* L.) Research in India: A scientometric journey through the last two decades (2000–2022), Ann. Arid Zone. 62 (2023) 1-17, https://doi.org/10.59512/aaz.2023.62.1.1

Onyike, N. B., Nelson, P. E., & Marasas, W. F. O. (1991). *Fusarium* species associated with millet grain from Nigeria, Lesotho, and Zimbabwe. *Mycologia*, *83*(6), 708-712, https://doi.org/10.1080/00275514.1991.12026076

Wilson, J. P., Z. Jurjevic, W. W. Hanna, D. M. Wilson, T. L. Potter, and A. E. Coy. "Host-specific variation in infection by toxigenic fungi and contamination by mycotoxins in pearl millet and corn." *Mycopathologia* 161 (2006): 101-107.

Xu, J., Kong, F., Zhang, H., Zhang, W., Wu, H., & Chen, G. (2023). First report of root rot caused by *Fusarium nygamai* on foxtail millet (*Setaria italica*) in China. *Plant Disease*, *107*(7), 2222.

Yadav, O., K. Rai, Genetic improvement of pearl millet in India, Agric. Res. 2 (2013) 275-292, https://doi.org/10.1007/s40003-013-0089-z

Volume: 04 Issue No: 12

BACTERIAL WILT IN TOMATO: PROVEN STRATEGIES TO PROTECT YOUR CROP

Article ID: AG-VO4-I12-135

***M. Karthikeyan, I. Johnson and M. Paramasivan**

Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nad, India

Corresponding Author Email ID:* karthikeyan.m@tnau.ac.in

Introduction

Tomato (*Solanum lycopersicum*), a versatile and widely cultivated vegetable, holds a significant place in global and Indian agriculture due to its nutritional value and extensive culinary uses. It is a rich source of vitamins A and C, minerals, and dietary fiber, making it a staple in households and the food processing industry. India, the second-largest producer of tomatoes, contributes 11% of global production, with a cultivation area of approximately 7.97 lakh hectares, yielding 18.39 million tonnes annually at an average productivity of 26 tonnes per hectare.

However, tomato cultivation faces challenges from several pest and disease threats, among which bacterial wilt caused by *Ralstonia solanacearum* is the most devastating. This soil-borne pathogen affects a wide range of crops globally, including tomato, potato, banana, and brinjal, causing yield losses of up to 90%. The disease has become a major concern due to its rapid spread, the adaptability of the pathogen, and the lack of complete resistance in commercial tomato varieties.

Global Status

Ralstonia solanacearum is ranked among the top ten most destructive plant pathogens worldwide, impacting over 200 plant species across 50 botanical families. Its ability to survive in soil and water for extended periods, coupled with its wide host range, makes it a formidable challenge for farmers. Yield losses exceeding $950 million annually have been reported, with severe outbreaks documented in regions like Uganda, Southeast Asia, and South America.

Indian Scenario

In India, bacterial wilt is endemic in several states, including Kerala, Karnataka, Gujarat, and West Bengal, affecting crops like tomato, brinjal, and potato. Yield losses in tomato due to this disease range from 10% to 100%, depending on environmental conditions and crop management practices. The acidic and alfisol soils in regions like Jharkhand exacerbate the disease's impact, leading to substantial economic losses.

Status in Tamil Nadu

Although bacterial wilt was not historically prevalent in Tamil Nadu, recent reports have indicated its emergence in crops like tomato and brinjal. Studies by researchers have documented outbreaks in major tomato-growing regions, highlighting the need for vigilant monitoring and effective management strategies.

The growing threat of bacterial wilt underscores the importance of integrated disease management practices to sustain tomato production and protect farmers' livelihoods.

Symptoms of Bacterial Wilt

Bacterial wilt, caused by *Ralstonia solanacearum*, is one of the most destructive diseases affecting tomato and other crops globally. The disease can cause rapid and severe wilting of plants, often leading to complete crop loss. The symptoms are categorized into external and internal manifestations, which vary based on the host plant, environmental conditions, and virulence of the pathogen.

External Symptoms

1. **Wilting:**
    - The earliest symptom is a sudden drooping or wilting of the youngest leaves during the hottest part of the day, which may recover during the cooler hours of the evening or night.
    - As the disease progresses, wilting becomes permanent and affects the entire plant.
2. **Leaf Symptoms:**
    - Leaves show epinasty (downward curling), which is a distinct symptom caused by blockage in the vascular tissues.
    - In some cases, leaves may turn yellow before wilting, but this is not always observed.

3. **Stem Rot and Adventitious Roots:**
   - Advanced stages of infection lead to stem softening and eventual rotting, particularly at the base.
   - The formation of adventitious roots on the stem near the soil line is common in infected plants, indicating stress in water and nutrient transport.
4. **Plant Death:**
   - In severe infections, plants collapse entirely and die within a short period, often with green foliage intact.

Internal Symptoms

1. **Vascular Discoloration:**
   - When stems of infected plants are cut crosswise, the vascular tissues appear dark brown or black due to colonization by the pathogen.
2. **Bacterial Ooze:**
   - A characteristic white or yellowish slimy bacterial exudate can be observed when cut stem segments are suspended in clean water for a few minutes. The exudate flows from the vascular bundles, indicating high bacterial load.
3. **Root Symptoms:**
   - Despite severe infection in the stem and foliage, the root system often remains relatively healthy and intact.
4. **Progressive Symptoms:**
   - Infected plants show progressive discoloration of the vascular system, which extends through the pith and cortex until complete necrosis occurs.

Pathogen Characteristics

Ralstonia solanacearum is a Gram-negative, rod-shaped bacterium that is highly adapted to a wide range of environmental conditions and plant hosts.

Morphology and Physiology

1. **Physical Characteristics:**
   - The bacterium measures 0.5 to 0.7 µm in diameter and 1.5 to 2.5 µm in length.
   - It is motile, possessing a single polar flagellum, which aids in its movement through soil and water.

2. **Gram-Negative Bacterium:**
    - The bacterium is Gram-negative, with a thin peptidoglycan layer in its cell wall.
3. **Colony Morphology:**
    - On selective media such as triphenyltetrazolium chloride (TTC) agar, *R. solanacearum* forms characteristic colonies that are fluidal and white with a pink center due to the production of oxidized tetrazolium.
4. **Exopolysaccharides (EPS):**
    - The pathogen produces abundant exopolysaccharides, which contribute to its virulence by blocking xylem vessels, resulting in wilting symptoms.

Genetic Diversity

1. **Races and Biovars:**
    - The pathogen is divided into five races based on host range and five biovars based on carbohydrate utilization patterns.
    - Race 1 infects a broad range of solanaceous crops, including tomato, potato, and brinjal.
    - Biovar 3 is commonly associated with bacterial wilt in tomatoes in India.
2. **Phylotypes:**
    - Genomic studies have classified *R. solanacearum* into four phylotypes based on geographic origin:
        - Phylotype I: Asia
        - Phylotype II: Americas
        - Phylotype III: Africa
        - Phylotype IV: Indonesia and nearby islands
3. **Virulence Factors:**
    - The pathogen secretes cell wall-degrading enzymes (CWDEs), such as cellulases, pectinases, and proteases, that break down plant cell walls and facilitate colonization.
    - The Type III secretion system delivers effector proteins into plant cells, disrupting their defense mechanisms.

Mode of Spread

Ralstonia solanacearum is a highly versatile pathogen capable of spreading through multiple pathways, making its control particularly challenging.

Primary Sources of Inoculum

1. **Soil:**
   - The bacterium survives in soil for extended periods as a saprophyte or within infected plant debris.
2. **Irrigation Water:**
   - Contaminated water is a major source of inoculum, particularly in areas with high water table levels or flooding.
3. **Infected Plant Materials:**
   - Transplants, seeds, or vegetative propagules from infected plants serve as a direct source of inoculum.
4. **Weeds:**
   - Certain weed species act as asymptomatic reservoirs of the pathogen, maintaining its population between cropping seasons.

Secondary Spread

1. **Field-to-Field Movement:**
   - The pathogen spreads between fields through farm machinery, tools, and footwear.
2. **Root Damage:**
   - Entry points such as wounds caused by nematodes, insect pests, or mechanical injury facilitate infection.
3. **Runoff and Rain Splash:**
   - Surface water runoff and rain splash can disseminate the bacterium over long distances.
4. **Vectors:**
   - Soil-dwelling organisms such as nematodes and insects can carry the bacterium to healthy plants.

Favorable Conditions for Disease Development

The development of bacterial wilt is influenced by environmental, soil, and host factors that create a conducive environment for the pathogen.

Environmental Factors

1. **Temperature:**
   - High temperatures (25°C to 35°C) favor the growth and multiplication of *R. solanacearum*.
   - Disease incidence decreases at temperatures below 18°C or above 40°C.
2. **Humidity:**
   - High relative humidity accelerates disease progression.
3. **Rainfall:**
   - Heavy rainfall, particularly in tropical and subtropical regions, creates favorable conditions by increasing soil moisture and facilitating the spread of the pathogen.

Soil Factors

1. **Moisture Content:**
   - Waterlogged soils provide ideal conditions for the pathogen's movement and infection.
2. **Soil Type:**
   - Light, sandy soils with poor drainage are particularly susceptible to bacterial wilt outbreaks.
3. **pH Levels:**
   - Neutral to slightly acidic soils (pH 5.5 to 7.0) support pathogen survival and virulence.

Host-Related Factors

1. **Susceptibility:**
   - The lack of resistance in many commercial tomato varieties makes them vulnerable to infection.
2. **Root Wounds:**
   - Damage caused by nematodes, insects, or mechanical operations increases the likelihood of infection.
3. **Host Stress:**
   - Stress factors such as drought or nutrient deficiency exacerbate the disease.

Bacterial wilt caused by *Ralstonia solanacearum* is a highly destructive disease with complex symptomatology, diverse pathogen characteristics, multiple modes of spread, and a strong dependence on favorable environmental conditions. Effective management requires an integrated approach combining resistant varieties, cultural practices, and biological control to mitigate the impact of this devastating disease on tomato and other crops.

Management of Bacterial Wilt Disease Incited by *R. solanacearum*

The Antagonistic Potential of PGPR Against *R. solanacearum*

Bacterial wilt disease caused by *R. solanacearum* is a devastating issue for tomato production globally. The pathogen is highly aggressive and can lead to total crop loss, particularly when environmental conditions are favorable. Managing this disease remains challenging due to the lack of effective control methods. Traditional approaches, such as the use of resistant cultivars, chemical treatments, and cultural practices, have shown limited success. For instance, despite the development of resistant tomato varieties, their resistance is often location-specific, dependent on soil types, climatic conditions, and the virulence of the pathogen. Moreover, chemical treatments, including antibiotics and copper-based bactericides, have exhibited only minimal impact on controlling *R. solanacearum* in field conditions, leading to the exploration of alternative strategies, particularly the use of plant growth-promoting rhizobacteria (PGPR).

PGPR are naturally occurring microorganisms in the rhizosphere that promote plant growth and offer protection against various pathogens, including *R. solanacearum*. These beneficial microbes interact with plants in several ways, enhancing plant growth, inducing systemic resistance, and suppressing pathogen activity. The antagonistic activity of PGPR, particularly fluorescent *Pseudomonas* species, has been extensively studied and proven effective in controlling bacterial wilt. Various mechanisms underlie the ability of PGPR to suppress *R. solanacearum*, including competition for nutrients and space, production of antimicrobial compounds, and the induction of plant resistance.

Fluorescent *Pseudomonas* spp., such as *P. fluorescens* and *P. mosselii*, have shown promise in reducing the incidence of bacterial wilt in tomatoes and other crops. These bacteria produce a range of antimicrobial substances, including siderophores, hydrogen cyanide, and antibiotics like DAPG (2,4-diacetylphloroglucinol), which inhibit the growth of *R. solanacearum*. In laboratory conditions, *P. fluorescens* has been reported to significantly reduce bacterial wilt by competing with the pathogen for iron and other essential resources, thus limiting pathogen growth. Additionally, PGPR can trigger systemic resistance in plants, enhancing their defense mechanisms against bacterial and other types of infections.

In greenhouse trials, *Pseudomonas* strains have demonstrated a significant reduction in the disease incidence of bacterial wilt, with some studies showing up to 70% reduction in wilt symptoms. The ability of *P. fluorescens* to suppress the pathogen and enhance plant health under stressful conditions makes it an attractive candidate for integrated disease management strategies.

Moreover, PGPR-induced plant growth promotion is another key benefit. PGPR can produce plant hormones such as cytokinin, indole-3-acetic acid (IAA), and gibberellins, which stimulate plant growth and improve overall plant vigor. These bacteria can also break down plant-produced ethylene, a stress hormone that accumulates during pathogen attacks, thus improving plant resilience. Recent studies have further identified bacterial volatiles like acetoin and 2,3-butanediol that enhance plant growth and induce resistance against pathogens.

While PGPR-based biocontrol has proven successful under controlled conditions, translating these results to field conditions presents challenges due to environmental variability and the complexity of microbial interactions in the soil. Nonetheless, continued research into the diverse mechanisms of PGPR and their integration with other management practices holds significant promise for managing bacterial wilt in tomato.

Chemical Management of *R. solanacearum*

The use of chemical control methods, including pesticides and bactericides, has been a traditional approach to manage bacterial wilt caused by *R. solanacearum*. While these chemicals can offer short-term relief, their long-term effectiveness and potential environmental impact are concerns that limit their widespread use. Pesticides, including fumigants and systemic plant activators, have shown varying levels of success in reducing bacterial wilt and improving yields, but they are not a panacea for the disease.

Fumigants like methyl bromide, 1,3-dichloropropene, and chloropicrin have been used to reduce the bacterial load in the soil and control the pathogen in affected fields. These chemicals can significantly increase yields and reduce the incidence of bacterial wilt by up to 100% in some cases. However, their environmental toxicity, persistence in the soil, and regulatory restrictions have prompted a search for safer alternatives.

In addition to fumigants, plant activators such as validamycin A and validoxylamine have been used to induce systemic resistance in tomato plants, thereby enhancing their ability to fight off bacterial infections. These chemicals have shown promise in reducing disease severity and improving plant health, though their application must be carefully managed to avoid detrimental effects on plant growth.

Bactericides, such as streptomycin sulfate and triazolothiadiazine, have been tested for their ability to control *R. solanacearum*. While these chemicals can suppress the pathogen to some extent, their efficacy is often limited, and resistance to these chemicals can develop over time. Streptomycin, in particular, has been shown to have minimal effect on bacterial wilt incidence, especially in field conditions where pathogen populations are high and environmental factors are less controlled.

While chemical treatments can help manage bacterial wilt, they come with a range of drawbacks. Over-reliance on chemical pesticides can lead to environmental pollution, resistance development in pathogens, and harm to beneficial soil organisms. Additionally, the cost of chemical control, along with the potential for harmful residues in food crops, has led to increased interest in more sustainable alternatives.

As a result, integrated management strategies that combine chemical control with biological and cultural practices are often the most effective way to manage bacterial wilt. These strategies involve using resistant cultivars, crop rotation with non-host plants, soil fumigation, and the application of biocontrol agents like PGPR. By combining these approaches, farmers can reduce their reliance on harmful chemicals while managing bacterial wilt more effectively.

Integrated Disease Management

Given the complexity of bacterial wilt and the challenges associated with its control, an integrated disease management (IDM) approach is considered the most effective strategy for managing *R. solanacearum* in tomato cultivation. IDM combines multiple methods, including the use of resistant varieties, cultural practices, biological control, and chemical treatments, to provide a more holistic and sustainable solution to bacterial wilt.

Cultural practices, such as crop rotation with non-host plants, can help reduce pathogen populations in the soil. While *R. solanacearum* can persist in soil for extended periods, rotating with crops that do not host the pathogen can help break the disease cycle and reduce the pathogen load. Additionally, the use of clean planting material and proper sanitation practices can prevent the spread of the pathogen within fields.

Incorporating PGPR into IDM systems has gained popularity as an environmentally friendly approach to disease management. PGPR not only suppress *R. solanacearum* but also improve plant growth and resistance, leading to healthier plants that are better able to tolerate bacterial wilt and other stressors. The use of PGPR in conjunction with chemical and cultural practices can provide a more robust defense against bacterial wilt, helping to maintain tomato yields in areas affected by the disease.

Lastly, monitoring and early detection of bacterial wilt symptoms are critical for implementing timely control measures. Regular field inspections and the use of diagnostic tools can help identify disease outbreaks before they spread, allowing for quicker intervention and minimizing crop losses.

In conclusion, while managing bacterial wilt caused by *R. solanacearum* remains a challenge, advances in biocontrol, especially through the use of PGPR, offer promising alternatives to chemical control. By combining biocontrol agents with other management practices, including cultural methods and selective pesticide use, farmers can effectively manage bacterial wilt and reduce its impact on tomato production. This integrated approach not only improves disease control but also contributes to more sustainable agricultural practices.

Volume: 04 Issue No: 12

BIOCHAR: A SUSTAINABLE SOLUTION FOR CLIMATE CHANGE MITIGATION

Article ID: AG-V04-I12-136

***C.Pradipa[1], S. Sachin[2] and S.Kavitha[3]**

[1] Research Associate, Agro Climate Research Centre, TNAU

[2] SRF, Agro Climate Research Centre, TNAU

[3] Associate Professor (SST), CSW, TNAU, Coimbatore, Tamil Nadu, India

*Corresponding Author Email ID: pradipachinnasamy@gmail.com

Introduction

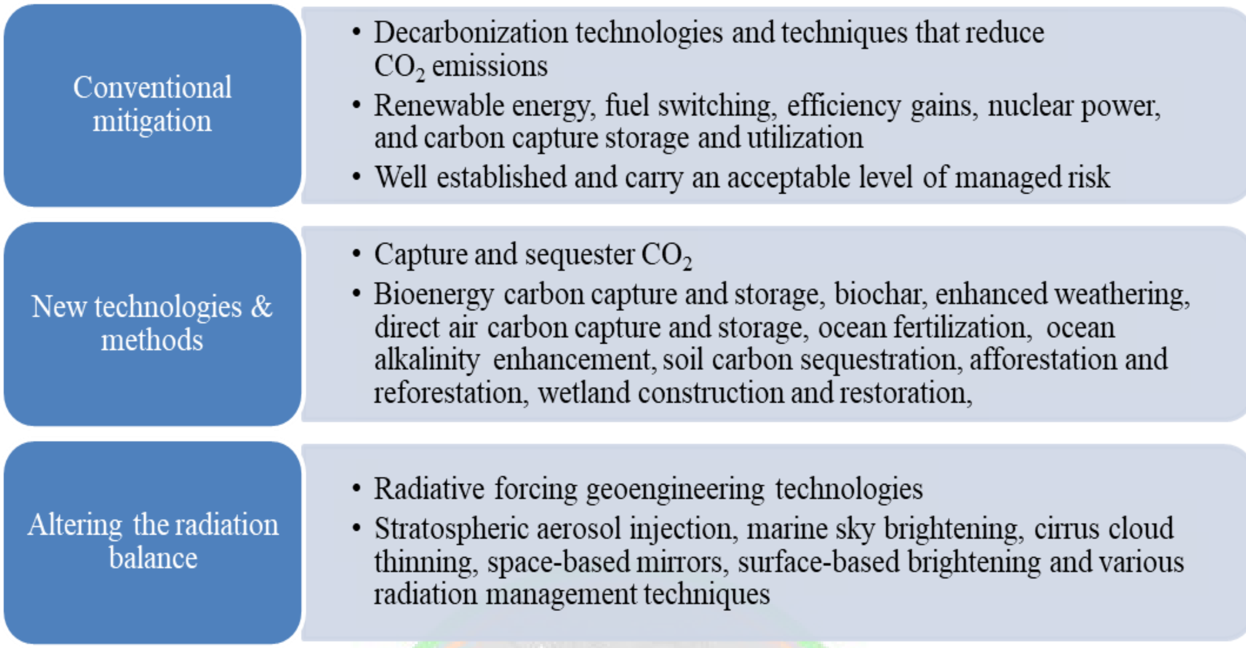
One of the complex problems that the whole world is facing in the recent years is the changing climate. It is a global problem that is felt everywhere and every individual in the world in any form *viz.*, social, scientific, economic, political, ethical problems. The Green House Gases (GHG) are mainly targeted for the reason behind the warming of the globe. The main underling cause for this is the human activities that release carbon dioxide, methane, nitrous oxide, CFCs and many others.

There are two approaches to attain the committed levels of GHG in the atmosphere as per Kyoto protocol.

1. Mitigation – reduction in GHG production and emission, capturing and storage and stabilization of GHG concentration in the atmosphere
2. Adaptation – technologies to adapt to the changing climate.

Prevention or reduction of green house gas emission is termed as mitigation. It includes identification of energy efficient technologies or technologies that can lead to increase in efficiency of water, carbon and energy.It also includes management techniques that can cut down the emission of the green house gases, techniques that can accumulate more carbon in more stabilized forms and act as sink for carbon.

There are three main approaches to mitigate climate change.



Biochar

Biochar is a C-rich product of the pyrolysis process that is used for making liquid biofuels or electricity via heating plant material at temperatures above 300°C anaerobically. Most C in biochar is highly stable because of its polycyclic and aromatic structures with high aryl C contents and high C/N ratios. Interest in using biochar for various purposes, including land restoration and climate-change mitigation, is being growing. How long biochar can remain in soils is uncertain and subject to many factors, but estimates of its half-life range from centuries to millennia. For example, biochar that are several thousand years older than nonblack C in some soils exist. This timescale of biochar stability could contribute to efforts to achieve net-zero GHG emissions in the next few decades to avert harmful climate impacts (Woolf *et al*., 2021).

Abandoned farmland restored to forest or grassland can form a closed "biochar-to-soil" system that continually removes CO_2 from the atmosphere and stores it in soil and plants. Life-cycle analyses of such biochar-to-soil systems have generally found substantial net GHG savings. In this system, forest residues and perennial grasses are used as feedstocks, and small-scale or mobile pyrolysis facilities convert them to biochar, which is then returned to the soil. Besides producing biochar, pyrolysis also produces tar and gas, which can be used on site (e.g., for process heat) or further processed for making biogas or bio-oil to displace fossil fuels. For forests, removing residues can reduce wildfire risks which are increasingly exacerbated by climate change and enhance stand health. But forest residues also provide important habitats for certain fungi and wildlife, recycle nutrients, and help maintain soil moisture. These ecological and hydrological benefits of forest residues must be considered in determining how much residue should be removed for biochar use. For grassland, late-season harvest has no effect on the diversity of plant species, suggesting that proper management can conserve biodiversity while supplying biomass for biochar and C sequestration (Rawat *et al*., 2019).

Besides being an external C input, biochar can decrease soil CO_2, CH_4, and N_2O fluxes, but large uncertainties remain. First, biochar can increase or decrease decomposition of soil organic matter by stimulating or inhibiting microbial activities, also known as positive or negative soil-priming effects, respectively. The positive priming effect is generally short lived, whereas the negative priming effect occurs more often. The negative effect is attributed to the protection of soil organic matter from microbial consumption via chemical adsorption on the biochar surface, the promotion of organo-mineral associations, or the formation of soil aggregates. As with CO_2 emissions, there exist a conflicting result on the effects of biochar on soil CH_4 and N_2O emissions. For example, biochar reduced CH_4 emissions in paddy soils by ~50%–90% as a result of the increased abundance of methanotrophic proteobacteria and inhibition of methanogenic archaeal growth, whereas there are results showing significantly increased CH_4 emissions and decreased N_2O emissions in paddy soils. The negative effect of biochar on N_2O emissions could be due to a biochar-induced increase in the abundance of N_2-fixing microorganisms and improvement in microbial reduction of nitrous oxide (Li *et al*., 2022).

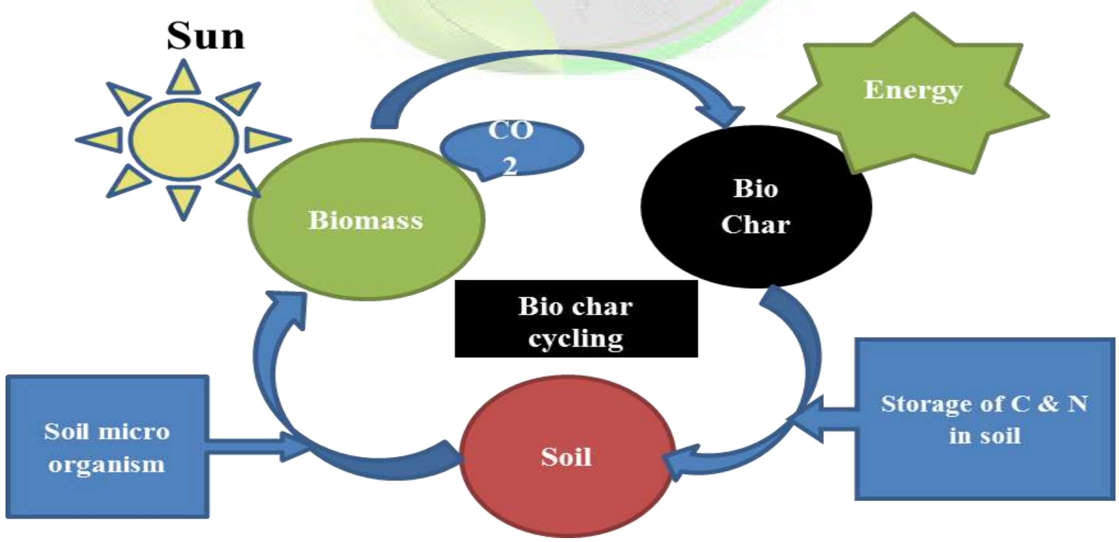


Figure: Use of biochar in atmospheric C reduction

Benefits of Biochar

- **Carbon Sequestration**: Biochar acts as a carbon sink, capturing carbon dioxide from the atmosphere and storing it in the soil. This helps to reduce the overall concentration of greenhouse gases.
- **Soil Enhancement**: When added to soil, biochar improves its structure, water retention, and nutrient-holding capacity. This leads to healthier plants and increased agricultural productivity.
- **Reduction of Greenhouse Gas Emissions**: Biochar application can reduce emissions of nitrous oxide and methane, two potent greenhouse gases, from agricultural soils and landfills.
- **Waste Management**: Producing biochar from organic waste materials helps in waste reduction and recycling, thus contributing to sustainable waste management practices.

We need to better understand the mechanisms by which biochar affects soil, GHG fluxes, especially how different abiotic and biotic factors contribute to such effects, to determine the total GHG-mitigation potential of biochar applied to degraded soils and to inform restoration efforts that minimize the negative impacts of biochar and maximize its positive impacts.

Volume: 04 Issue No: 12

REVOLUTIONIZING FARM MECHANIZATION WITH MACHINE LEARNING

Article ID: AG-V04-I12-137

Meena. R[1*], P. Kamaraj[2], R. Thiyagarajan[3] and M. Mathialagan[4]
[1]Postgraduate Research Scholar, [2]Associate Professor, [3]Associate Professor and Head
Department of Farm Machinery and Power Engineering, Agricultural Engineering College and Research Institute, TNAU, Tamil Nadu.
[4]Assistant professor (Entomology), Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu, India
*Corresponding Author Email ID: meenarajendranselva005@gmail.com

Introduction

As the global population continues to raise, the demand for food production has reached unprecedented levels. Traditional farming methods, which depend heavily on manual labor and resources, are finding it increasingly difficult to meet the demands of modern agriculture. This is where machine learning (ML) comes in, offering a transformative solution. By harnessing the power of data and predictive analytics, ML enables farmers to make informed decisions that optimize their operations. From improving crop yields and enhancing soil health to predicting pest infestations and reducing water usage, ML helps farmers to do more with less. This not only leads to cost savings but also supports sustainable farming practices, reducing the environmental impact. As farms become more data-driven, ML is making agriculture smarter, more efficient, and more resilient, empowering farmers to tackle challenges like never before.

Application of Machine Learning in Farm Mechanization

1. Enhancing Precision in Farm Operations

Traditional farming often relies on the farmer's knowledge and experience, but this can sometimes result in mistakes or less-than-ideal outcomes. Factors such as changing weather conditions or unfamiliar soil types can create challenges, resulting in inconsistent crop outcomes. Machine learning, however, introduces a more data-driven approach. It processes large datasets from various sources like sensors, drones, and IoT devices to provide farmers with precise insights. This technological shift helps farmers make better-informed decisions, reducing the reliance on guesswork and increasing the accuracy of their farming practices. By using these insights, farmers can optimize their strategies and improve productivity, leading to better harvests.

For example, autonomous tractors powered by machine learning can analyze terrain data and adjust their navigation systems accordingly. By evaluating the landscape, these tractors optimize their routes, reducing fuel consumption and operational time. This not only makes farming more efficient but also cuts down on operational costs. Additionally, smart seeding machines, powered by predictive models, can determine the ideal planting depths and spacing based on real-time soil conditions, such as moisture levels and soil type. This ensures that seeds are placed optimally, leading to better germination rates and maximizing crop yields. By using these technologies, farmers can achieve more consistent and higher yields while minimizing waste.

2. Predictive Maintenance of Machinery

When farm machinery breaks down, it can cause unexpected delays, putting pressure on tight farming schedules and potentially leading to significant losses.

Image source: CNR Team 2020

ML algorithms play a vital role in predictive maintenance by analyzing historical performance data and identifying patterns that precede equipment failure.

Machine learning (ML) can detect early warning signs of issues in farming equipment, like vibration changes in combine harvesters or unusual temperature shifts in irrigation pumps. By identifying these anomalies, ML alerts farmers to potential problems before they become serious. This allows for proactive maintenance, which helps prevent costly repairs, reduces downtime, and ensures the machinery operates efficiently for a longer period.

3. Automated Harvesting Systems

Harvesting is one of the most labor-intensive tasks in farming, but machine learning is making it easier through automated harvesting systems. These systems use computer vision, a key application of ML, to identify ripe produce with impressive accuracy. By recognizing when crops are ready for harvest, the technology helps farmers increase efficiency, reduce labor costs, and improve the quality of the harvested produce.

For example, Robotic arms using machine learning are designed to recognize ripe fruits, picking only the ones that are perfectly matured. This technology reduces waste by ensuring that only high-quality produce is harvested. It also helps address the labor shortages that many farmers face, making the process more efficient and less reliant on manual labor, which is becoming harder to find.

4. Optimizing Irrigation and Resource Management

Machine learning-based irrigation systems are helping farmers tackle water scarcity by using advanced data analysis. These systems take into account weather forecasts, soil moisture levels, and the specific water needs of crops, allowing for precise irrigation. As a result, water is used more efficiently, reducing waste while still ensuring healthy crop yields. This technology supports sustainable farming practices, helping farmers conserve water and maintain productivity.

Moreover, Machine learning plays a key role in efficient nutrient management by using data from soil sensors to accurately assess the nutrient needs of crops. This allows farmers to apply fertilizers precisely where and when they're needed, reducing waste and minimizing the environmental impact. As a result, crops receive the right balance of nutrients for optimal growth, leading to healthier harvests and more sustainable farming practices.

5. Weed and Pest Management

Weed and pest infestations are major challenges that can lower crop yields, but machine learning is helping to address this issue effectively. With the help of computer vision and image recognition, ML systems can detect weeds and pests in real-time. This allows farmers to take immediate, targeted action, addressing problems before they spread. Autonomous weeders, for example, can remove weeds with precision without harming crops. This reduces the need for chemical herbicides, which is not only better for the environment but also supports sustainable farming practices. By using these advanced technologies, farmers can ensure their crops remain healthy while minimizing environmental harm. As a result, this technology makes farming more efficient and eco-friendly.

In pest management, machine learning is becoming an essential tool for farmers. By using environmental data like temperature, humidity, and weather forecasts, ML models can predict when pests are most likely to affect crops. This helps farmers take action before the pests cause significant damage. With predictive insights, farmers can apply targeted pest control measures, reducing the need for widespread pesticide use. By focusing on early intervention and prevention, farmers can protect crops in a way that promotes long-term sustainability. This approach not only leads to healthier crops but also supports eco-friendly farming practices, ensuring both economic and environmental benefits.

ML applications in farm mechanization, such as a tractor equipped with IoT sensors, a robotic arm harvesting crops, and an ML-powered irrigation system.

6. Supporting Sustainable Farming Practices

Machine learning plays a crucial role in fostering sustainability by reducing resource wastage and improving energy efficiency in farming. By integrating data from various sources such as satellite imagery, drone surveillance, and ground sensors, ML allows farmers to practice precision farming. This means resources like water, fertilizers, and pesticides are used more effectively, minimizing waste. By analyzing data on soil health and weather patterns, ML helps farmers make better decisions on when and how much to apply, thereby reducing the ecological impact of their farming practices. This leads to a more sustainable, productive agricultural system that benefits both farmers and the environment.

For instance, ML algorithms can analyze historical yield data and recommend crop rotations that improve soil health and prevent overuse of the land. These data-driven suggestions ensure that the soil remains fertile and productive for future seasons. Furthermore, solar-powered farm equipment integrated with ML ensures that energy use is optimized, reducing the reliance on non-renewable energy sources. By automatically adjusting operations based on real-time data, ML ensures that energy is used efficiently, making farming more eco-friendly. Overall, this holistic approach contributes to the long-term sustainability of agricultural practices while improving productivity.

Challenges and Future Directions

While machine learning is clearly making a big impact in farm mechanization, there are still some hurdles to overcome. High initial investment costs, limited internet connectivity in rural areas, and the need for specialized skills to implement ML solutions are significant barriers. However, with government support, public-private partnerships, and advancements in affordable technologies, these challenges can be mitigated.

The future of machine learning in agriculture is full of exciting possibilities. New technologies like edge computing and federated learning are making it easier and more efficient for farmers to use ML tools. As more data is shared and connected across different systems, the accuracy of these tools will keep improving, leading to even smarter innovations in farming. This progress will drive more efficient farm mechanization and help farmers adapt to the challenges of modern agriculture.

Conclusion

Machine learning is reshaping farm mechanization by offering greater precision, efficiency, and sustainability. Through innovations like autonomous tractors that can operate without human intervention and predictive maintenance systems that alert farmers to potential machinery failures before they occur, ML is streamlining farm operations.

Additionally, ML models are optimizing resources like water and fertilizers, ensuring crops get exactly what they need while minimizing waste. In pest management, machine learning helps predict infestations and apply targeted solutions, reducing reliance on harmful chemicals.

By adopting these technologies, farmers not only enhance their productivity and reduce costs but also contribute to more sustainable farming practices. This shift towards smarter farming solutions is crucial as we face the global challenge of feeding a growing population while protecting the environment. With machine learning leading the way, the agricultural industry can achieve higher yields, better resource management, and more resilient farming systems. This technology is not just transforming farming it is helping create a future where food production is more efficient and environmentally friendly.

References

Sayed, H. A., Ding, Q., Abdelhamid, M. A., Alele, J. O., Alkhaled, A. Y., & Refai, M. (2022). Application of machine learning to study the agricultural mechanization of wheat farms in Egypt. *Agriculture*, *13*(1), 70.

Shinde, G. U., Mandal, S., Ghosh, P. K., Bhalerao, S., Kakade, O., Motapalukula, J., & Das, A. (2023). Farm Mechanization. In *Trajectory of 75 years of Indian Agriculture after Independence* (pp. 475-496). Singapore: Springer Nature Singapore.

Roman, S., & Wuepper, D. (2024). Agricultural Mechanization Around the World.

Rakhra, M., Singh, R., Lohani, T. K., & Shabaz, M. (2021). Metaheuristic and Machine Learning-Based Smart Engine for Renting and Sharing of Agriculture Equipment. *Mathematical Problems in Engineering*, *2021*(1), 5561065.

Mentsiev, A. U., Amirova, E. F., & Afanasev, N. V. (2020, August). Digitalization and mechanization in agriculture industry. In *IOP Conference Series: Earth and Environmental Science* (Vol. 548, No. 3, p. 032031). IOP Publishing.

Volume: 04 Issue No: 12

REVOLUTIONIZING RICE CULTIVATION: ADVANCED TRANSPLANTING TECHNOLOGY AT WORK IN A SUSTAINABLE PADDY FIELD

Article ID: AG-V04-I12-138

Meena. R[1*], P. Kamaraj[2], R. Thiyagarajan[3] and M. Mathialagan[4]

[1]Postgraduate Research Scholar, [2]Associate Professor, [3]Associate Professor and Head

Department of Farm Machinery and Power Engineering, Agricultural Engineering College and Research Institute, TNAU, Tamil Nadu.

[4]Assistant professor (Entomology), Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu.

*Corresponding Author Email ID: meenarajendranselva005@gmail.com

Introduction

Rice is the staple food for more than half of the global population, making it one of the most essential crops worldwide. However, traditional transplanting methods are labor-intensive and time-consuming. This creates challenges in efficiency and profitability, especially with growing food demands and a shrinking agricultural workforce. The introduction of mechanized and automated rice transplanting machines has significantly transformed paddy farming, making the process faster, more precise, and environmentally friendly. These innovations reduce physical strain on farmers and ensure optimal seedling depth and spacing, which are essential for healthy crop growth. Moreover, mechanization minimizes water and fertilizer usage, promoting sustainable farming practices. As these technologies become more affordable, even small-scale farmers can increase their productivity. By making rice farming less physically demanding, automation is also attracting younger generations back to agriculture, securing a sustainable future for both farmers and global food production.

Transforming Rice Transplanting: The Journey from Traditional to Modern Techniques

For centuries, rice farmers have transplanted seedlings by hand, which required long hours of bending over in the fields. This method, although effective, was physically demanding and time-consuming. It often took a team of 16 workers an entire day to transplant just one acre of rice. This labor-intensive process caused physical strain and discouraged younger generations from pursuing farming, making mechanization an important solution for sustainable rice production.

In the 1960s, Kubota Corporation in Japan introduced the first rice transplanting machine, which, though bulky at first, paved the way for modern technology. These machines made rice transplanting faster and less tiring. Today's machines have features like adjustable row spacing and consistent planting depth, making them more efficient. For example, a walk-behind transplanter can plant up to 10 rows at once, saving time and effort. Later on, riding-type transplanters were developed, taking mechanization to the next level. These machines allow farmers to sit while planting, reducing the strain of bending. They are faster and can cover larger areas, planting multiple rows at once. With adjustable settings for row spacing and planting depth, they ensure better rice growth. These advancements have made rice transplanting much easier and more efficient, helping farmers improve productivity and reduce physical strain.

Precision Farming: The Role of Automated Transplanters in Agriculture

Since the 2000s, automated rice transplanting machines have gained prominence, utilizing advanced technologies like GPS, cameras, and sensors to ensure each seedling is planted at the optimal depth and spacing. These systems not only enhance transplanting accuracy but also integrate fertilizer and irrigation management, optimizing resource use.

Artificial intelligence (AI) and computer vision are playing a crucial role in enhancing the efficiency of rice transplanting. These technologies allow for real-time monitoring, error detection, and immediate correction, ensuring the process is as precise as possible. AI algorithms are designed to analyze soil conditions and automatically adjust planting intervals to optimize seedling placement, thus creating the best possible environment for growth. This level of precision reduces the need for replanting and minimizes waste, directly contributing to better crop yields. The integration of AI also allows for predictive analysis, helping farmers make informed decisions about their fields, from watering schedules to pest management, further improving the overall farming process.

For instance, Automated transplanters have taken precision farming to a new level by incorporating advanced technologies such as GPS and inertial measurement units (IMU). These innovations enable a planting depth accuracy of ±2 cm, ensuring that each seedling is placed in the ideal location for optimal growth. This reduces plant gaps and allows for uniform growth, which leads to healthier crops and better yields. Furthermore, such technologies eliminate human error, which is common in manual transplanting methods. As these systems become more accessible, they provide farmers with the tools to not only increase productivity but also make farming a more sustainable and less labor-intensive profession, thus paving the way for the next generation of agricultural workers.

Environmental Sustainability: The Impact of Technology

With global emphasis on sustainable farming, modern rice transplanting machines are being designed to reduce environmental impact. Many newer models are powered by renewable energy sources like solar power, helping cut down on greenhouse gas emissions. For example, a solar-powered transplanter equipped with photovoltaic panels can operate for up to eight hours on a single charge. This is especially beneficial in regions with unreliable electricity, offering farmers a reliable, eco-friendly solution. The ability to harness renewable energy not only reduces operational costs but also aligns farming practices with broader environmental goals, supporting a cleaner, greener future for agriculture.

Automated rice transplanting machines also play a crucial role in improving soil health and reducing environmental harm. These machines use precision techniques to minimize soil compaction, which is a common problem in conventional farming practices. By reducing the pressure on soil, these machines help preserve its structure and fertility, promoting long-term productivity. Additionally, many modern machines incorporate microcontroller-based systems that allow for the precise application of chemical fertilizers like urea. This targeted approach ensures that fertilizers are applied only where needed, reducing excess use and nutrient runoff. The result is healthier soils, cleaner water, and a farming system that supports both the environment and sustainable food production.

Benefits of Modern Transplanting Technology

- **Increased Efficiency:** Mechanized and automated transplanters can plant over 10,000 seedlings per hour, compared to just 1,500 seedlings using traditional methods. This saves time and increase overall productivity.
- **Reduced Labor Costs:** Automation maintains planting precision while cutting labor costs by up to 45%, reducing the dependency on manual effort.
- **Lower Environmental Impact:** Solar-powered and battery-operated transplanters emit fewer greenhouse gases compared to petrol/diesel engines.

- **Enhanced Plant Health:** Accurate planting depth and spacing promote better root establishment, leading to improved yields and crop quality.

Challenges in Adopting New Technology

Despite the numerous benefits, the adoption of modern rice transplanting technologies faces several challenges, particularly for small-scale farmers. One significant obstacle is the high cost of automated transplanters, which can range from ₹20,000 to ₹50,000, making them inaccessible to many farmers, especially those with limited financial resources. Additionally, operating these machines requires skilled labor, and in many rural areas, the availability of proper training and technical support is limited. This lack of expertise means that even minor technical malfunctions can halt operations, which highlights the need for accessible training programs and local support systems to ensure the machines' efficient use.

Another challenge is the design of advanced transplanting machines, which are often built for large, uniform fields, a feature that is not always compatible with the smaller, irregularly shaped plots commonly found in countries like India. These large machines can struggle with navigating uneven terrain, reducing their effectiveness for smallholders. To make mechanization more inclusive, it’s crucial to develop compact, cost-effective machines tailored specifically for the needs of small farmers. Such machines would not only improve efficiency but also support the sustainable growth of agriculture in regions where small-scale farming is predominant.

Opportunities for the Future

The future of rice transplanting technology lies in making these innovations more affordable and user-friendly for small-scale farmers. Researchers are actively working to develop compact, low-maintenance machines that are easy to operate. Customizable designs based on field size and crop type are also gaining traction; ensuring machines meet the diverse needs of farmers.

Efforts are underway to integrate Internet of Things (IoT) devices and cloud-based monitoring systems into farming solutions. For example, IoT-enabled transplanters can collect critical data on planting depth, soil moisture, and seedling health, providing farmers with real-time insights for efficient decision-making. These advancements will help transform rice farming into a data-driven process, improving both productivity and sustainability.

Conclusion

The journey from traditional hand transplanting to mechanized and automated rice transplanting has revolutionized paddy farming. By adopting modern transplanting machines, farmers can reduce labor dependency, improve planting precision, and contribute to sustainable agricultural practices. While challenges remain, ongoing technological advancements and supportive policies are making these innovations more accessible to farmers. Ultimately, this transformation ensures food security while safeguarding the environment for future generations. The future of rice farming lies in the integration of precision, automation, and sustainability reshaping how we grow one of the world's most essential crops.

References

Bhatia M. P. K., (2022), Multipurpose Solarized Crop Transplanter, *IJRAR-International Journal of Research and Analytical Reviews (IJRAR)*, ***9*(2)**, 759-763.

Chand, A. A., Prasad, K. A., Mar, E., Dakai, S., Mamun, K. A., Islam, F. R., ... & Kumar, N. M. (2021). Design and analysis of photovoltaic powered battery-operated computer vision-based multi-purpose smart farming robot. *Agronomy*, *11*(3), 530.

Nagasaka Y., Tamaki K., Nishiwaki K., Saito M., Kikuchi Y., Kobayashi K., (2011), Autonomous rice field operation project in NARO, In *2011 IEEE International Conference on Mechatronics and Automation*, (pp. 870-874).

Nagasaka, Y., Saito, H., Tamaki, K., Seki, M., Kobayashi, K., & Taniwaki, K. (2009). An autonomous rice transplanter guided by global positioning system and inertial measurement unit. *Journal of field robotics*, *26*(6-7), 537-548.

Rahman, M. A., Yilmaz, I., Albadri, S. T., Salem, F. E., Dangott, B. J., Taner, C. B and Akkus, Z. (2023). Artificial intelligence advances in transplant pathology. *Bioengineering*, *10*(9), 1041.

Sharma, N. K., Anand, A., Budhlakoti, N., Mishra, D. C., & Jha, G. K. (2024). Artificial Intelligence and Machine Learning for Rice Improvement. In *Climate-Smart Rice Breeding* (pp. 273-300). Singapore: Springer Nature Singapore.

Yadav R., Patel M., Shukla S. P., Pund S., (2007), Ergonomic evaluation of manually operated six-row paddy transplanter, *International Agricultural Engineering Journal*, 16(3-4), 147-157.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

POST HARVEST PROFILE, PROCESSING AND WASTE UTILIZATION OF DRAGON FRUIT

Article ID: AG-VO4-I12-139

G. Keerthi Priya[1], K. Kumanan[2]*, A.Nithya Devi[3], M. Shanmugnathan[4] and S.Sheeba Joyce Roseleen[5]

[1, 2 & 4] Agricultural College and Research Institute, TNAU, Kudumiyanmalai, India

[3] Dr.M.S.S Agricultural College and Research Institute, TNAU, Eachankottai, India

[5] Horticultural College and Research Institute for Women, TNAU, Tiruchirappalli, India

*Corresponding Author Email ID: kumanan@tnau.ac.in

Introduction

Dragon fruit, also known as Pitaya, belongs to the Cactaceae family and is found in two genera 'Hylocereus' and 'Selenicereus'. The Hylocereus genus, which includes around 16 species, is the most widely cultivated. It is also called strawberry pear, Thangloy (Vietnamese), and Pitayaroja (Spanish) and La Pitahaya Rouge (French).Three commercially cultivated types include *Hylocereus undatus* (white dragon fruit), *Hylocereus polyrhizus* (red dragon fruit), and *Selenicereus megalanthus* (yellow dragon fruit). The fruit has significant potential in both domestic and foreign markets due to its ornamental value and table consumption. Growing dragon fruit has a 20-year lifespan and can support up to 800 plants per hectare. This is the most significant advantage. This perennial crop produces quickly, starting the following year and reaching peak capacity within 5 years.

Since, it is perishable, requiring extra attention from planting to harvesting, handling, storage, processing, and transportation to market distribution. Establishing an adequate marketing channel for transporting fresh fruit to remote locations is a significant problem due to its high demand. Fruits can be processed into many items such as juice, jam, jelly, powder, and wine. It holds significant nutritional and commercial value in the processing sector.

The different kinds of dragon fruit

White Dragon fruit

Red Dragon fruit

Blue Dragon fruit

Yellow Dragon

Sour Dragon fruit

Pink Dragon fruit

Dragon fruit is best consumed when harvested mature due to its non-climacteric character, as storage can reduce quality. At maximum maturity, it produces a large amount of little black seeds with a vivid red/yellow skin and white/coloured flesh. Flesh varies depending on the cultivar. It contains three main components: pulp (47.40-73.76%), peel (36.70-37.60%), and seed (2.70-14.67%). Fruit pulp is white, red, or purple. The fruit shows a red or yellow peel. Furthermore, the red colour of the peel is more intense in red dragon fruit than in white fruit. The seeds are small, soft, delicious, and black. These fruits produce a low rate of ethylene (0.03-0.09 µl/kg/h). Applying ethylene to fruit does not result in colour development. The maximum respiration rate (75-144 mg CO_2/kg/h at 20-23°C) occurs during the early stages of fruit development.

Maturity traits

The main indicator of maturity is a change in skin colour to red or yellow, depending on the variety. Other parameters include size, weight, soluble solids content (SSC), pulp betacyanins, and flavour rating, with minimum values for firmness and mucilage. Requirements include starch content, titratable acidity (TA), and at least 32 days post-flowering.. During the winter season, colour break occurs 30 days after flowering (DAF), and fruits are available for harvest at 33-34 days. During the summer season, colour break starts after 26 days and picking begins at 30 DAF. Some international buyers prefer less sweet dragon fruit. Fruit can be harvested before or after 31 DAF, depending on its sweetness level.

Harvesting and Grading

Fruit should be harvested when it reaches physiological maturity and has completed all developmental phases. The most popular harvesting method is to hand twist the fruit, which often destroys the skin. To avoid this, knife/secateurs can be used with a two-cut operation, or a single cut with shears. In addition to classification, fruits are graded by weight, Red and white dragon fruits are evaluated in nine different size codes, while yellow fruits are graded in five size codes. The grade also considers the number of fruits per 4-kg cardboard box, i.e. 6, 8, 10, 12, 14, or 16. It is currently graded manually, highlighting the need for better grading techniques that consider physical qualities, optical properties, and weight.

Grading of dragon fruit based on unit weight

Size code	Unit weight (g)	
	Red/White	**yellow**
A	110-150	110-150
B	151-200	151-200
C	201-250	201-260
D	251-300	261-360
E	301-400	>361
F	401-500	-
G	501-600	-
H	601-700	-
I	>701	-

Storage

The postharvest storage life of dragon fruit is regulated by respiration rate and physiological weight loss (PLW), with optimal storage temperatures of 10°C for *Hylocereus undatus* and *Hylocereus polyrhizus* and 6°C for yellow pitaya (*Selenicereus megalanthus*) at 85-90% relative humidity. While these circumstances can maintain quality for up to 21 days, higher temperatures (over 20°C) induce rapid softening and quality degradation, including decreased sugar and acidity. The difficulties in maintaining these conditions, particularly in countries such as India, where the majority of fruits are imported, underscore the need for improved handling, packing, and access to cold storage facilities to reduce transit losses and maintain quality across the supply chain.

Processing and Waste Utilization

Dragon fruit has high levels of antioxidants, fiber, vitamin C, minerals, calcium, and phosphorus in all parts (pulp, peel, seeds, flower buds, and dried flowers). Fruit peel possesses antimicrobial, natural coloring, and antioxidant properties in addition to the nutritious value of ripe fruit, the young stem and fresh blossom buds can be consumed as a vegetable. Dragon fruit petals were dehydrated and utilized to make an antioxidant-rich tea. Products are prepared with little processing to maintain their sensory qualities. Fruit pulp is used to create juice, wine, jam, jelly, and preserves. Peels can be used to extract natural food pigments, and seeds are a source of pectin. They are primarily used to extract oil, which contains around 50% of the necessary fatty acids.The seeds are used in various food products, including syrup, ice cream, sherbet, confectionery, yogurt, and pastries.

Nutritional composition of different parts of Dragon fruit

PARTICULARS	PULP	PEEL	SEEDS
Moisture (g/100 g of pulp)	82.5 – 89.4[d]	84.86–91.19[a,b]	12.6 ± 6[h]
pH value	4.26–4.98[c]	4.83–5.48[b]	3.1–6.1[k]
Dry matter (%)	12 ± 1[e]	NR	NR
Density 20°C (g/cm3)	1.02–1.04[c]	NR	NR
Titratable acidity (%)	3.15–6.85[c]	0.22–0.25[b]	NR
Total soluble solids (°Brix)	7.50–12.92[c]	7.15–12.77[b]	NR
Total soluble solids: Titratable acidity	10.93–35.20[c]	4.60–5.70[k]	NR
Pectin (mg/g)	0.64–1.36[c]	NR	NR
Fat content (%)	0.10–0.61[d]	0.02–0.07[b]	29.6 ± 6[h]
Ash content (%)	(%) 0.28–0.50[d]	14.29[a]	2.1 ± 1[h]
Mineral content	NR	0.17–0.22[b]	NR
Total phenolic content (mg/100 g)	3.75–19.72[g]	28.16–36.12[g]	1356 ± 2.04[i]

Total dietary fiber(g/100 g)	1.1–3.20[f]	69.30 ± 0.53[j]	30.2 ± 19[h]
Total ascorbic acid (mg/100 g)	13.0–55.80[f]	NR	NR
Total Vitamin C (g/1000 ml)	0.32–0.58[c]	0.0704–0.0762	0.0036 ± 0.01[i]
Protein content (g/100 ml)	12-12.5[e]	0.64–0.66[b], 0.95 ± 0.15[j]	20.6 ± 6[h]
Citric acid (g/100 ml)	9.5–21.1[c]	0.08 [j]	NR
Malic acid (g/100 ml)	60.8–82.0[c]	0.64 [j]	NR
Glucose (g/100 ml)	491.4–1039.5[c]	4.15 ± 0.03[j]	NR
Fructose (g/100 ml)	192.0–289.7[c]	0.86 ± 0.02 [j]	NR
Betacyanin content (mg/g of dm)	NR	41.55[a]	NR
Total carbohydrates (%)	NR	6.20 ± 0.09[j]	35.2 ± 15[h]

Value added and processed products from pulp

Juice

Enzymatic clarification techniques and optimized processing conditions are essential in increasing juice yield, clarity, and stability while retaining nutritional properties such as betacyanins, polyphenols, and antioxidants. The combination of procedures such as enzymatic treatment, low-temperature processing, and optimum storage conditions helps longer shelf life, increased consumer acceptability, and profitability for both consumer and industrial use.

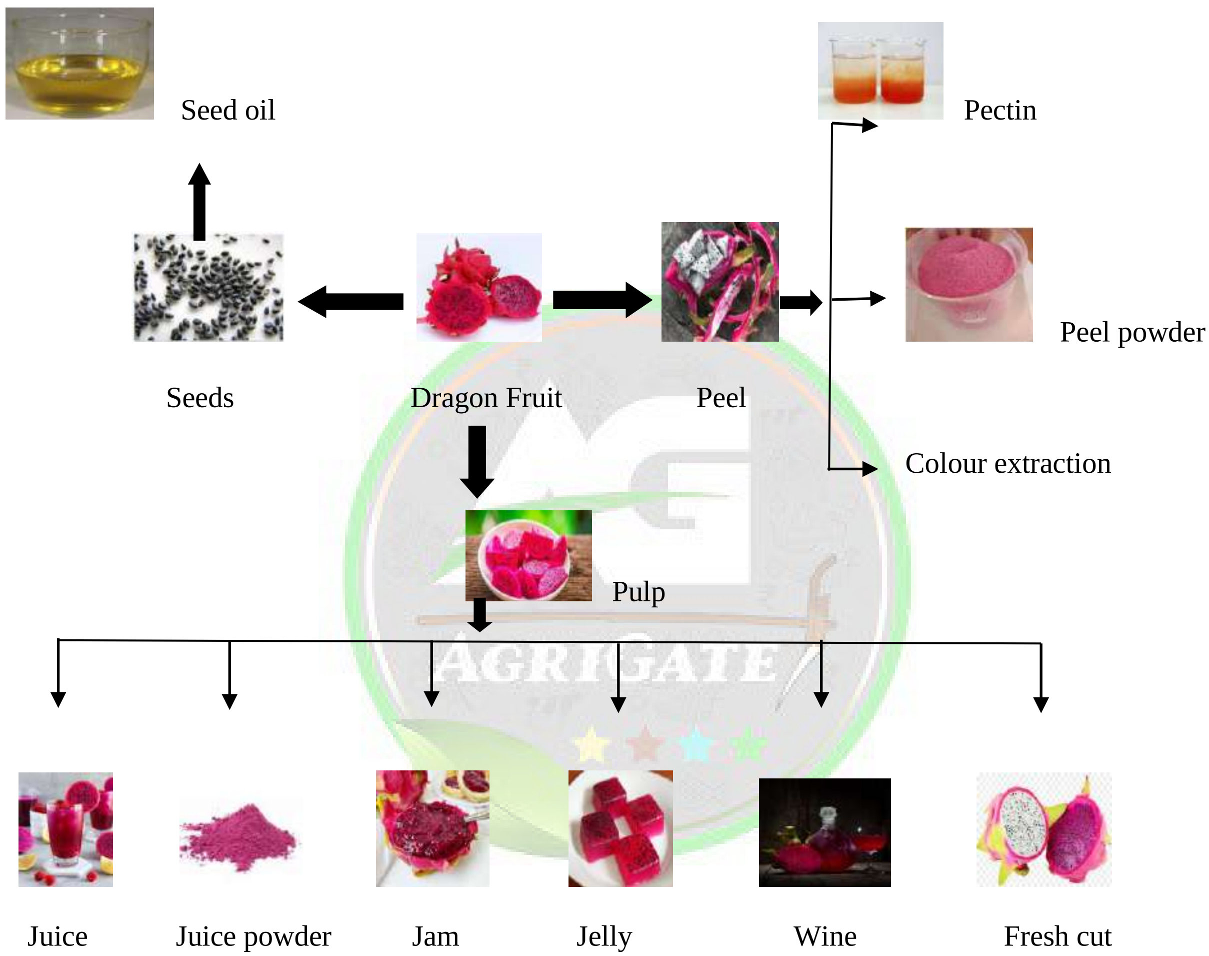
Juice powder

Dragon fruit powder, valued for its long shelf life and economic benefits, is commonly used as a natural colorant in functional food. Spray drying is an important method for producing nutrient-rich powder suitable for environmental storage and transportation, however stickiness and flow issues can be reduced by carrier components such as maltodextrin. The optimal drying conditions vary, with an intake temperature of 155-180°C and 20-30% maltodextrin producing fine powder or retaining betacyanin. Proper storage at 33% RH maintains antioxidant capabilities while preventing structural breakdown.

Wine

Dragon fruit juice fermentation increases shelf life, improves flavor, and boosts antioxidant potential while enhancing bioactive components such as betacyanins, phytosterols, and phenols. Pasteurization (75°C for 15 seconds) improves nutritional value and ensures safety.

Wine preparation with ideal yeast compositions (e.g., 50% S. oviformis and 50% S. vini) leads to enhanced sensory properties. Fermented drinks retain 80% of betanin when stored at 4°C for 8 weeks and remain highly palatable to customers, suggesting their potential as value-added products.



Various valued and processed products

Fresh cut or minimal processing

Dragon fruit has showed potential in terms of quality preservation and shelf life extension with minimal preparation. Cutting and slicing techniques, when paired with edible coatings such as low molecular weight chitosan, assist maintain organoleptic, visual, and microbiological quality during low-temperature storage (4°C or 8°C). Chitosan-coated fruits preserve important characteristics such as soluble solids content (SSC), titratable acidity (TA), ascorbic acid levels, and flavour, while inhibiting microbial development and surface browning. Additionally, osmotic dehydration and particular packaging procedures improve shelf life and marketability. However, post-harvest timing and storage conditions have a considerable impact on the quality and endurance of fresh-cut goods, with earlier processing producing superior outcomes. These improvements in preparation and storage techniques create way for increased commercialization of dragon fruit in both fresh-cut and frozen forms.

Seed separation and oil extraction

Seed separation using autoclaving and vigorous shaking in water, followed by drying and grinding for oil extraction with petroleum ether, yields 29.5–32% oil. Enzyme-assisted liquefaction for easy seed recovery, antioxidant activity, finding ethanolic extracts exhibited high radical scavenging activity (74.76%). The high linoleic acid content of dragon seed oil, beneficial for skin health. Optimized oil recovery is obtained through cold extraction after mucilage removal.

Value added and processed products from peel

Peel powder and Pectin

Dragon fruit peel, a by-product of processing, is rich in bioactive compounds like pectin, phenols, antioxidants, and dietary fibre, making it a valuable resource for functional food applications. Spray and freeze drying methods help retain its nutritional qualities, though they are cost-intensive. Studies highlight its potential as a natural colorant, thickener, and texture agent, comparable to commercial products like guar gum. Peel powder can enhance the nutritional value of bakery products, such as cookies, without compromising sensory qualities. Advanced techniques like microwave-assisted extraction (MAE) efficiently extract bioactives like betalains and polyphenols.

Conclusion

Dragon fruit is a new fruit crop in nations like India, and its production area is growing these days. Even while fresh fruit is now only available in certain locations and during certain seasons, there is a great deal of scope for both domestic and foreign marketing. Because of its nutritional and functional qualities, pitaya may help lower the chance of developing chronic illnesses. Future markets will experience an increasing demand for colorants that are taken from natural sources, such as pitaya peel. In contrast to red beet, which has negative connotations because of its high nitrate and geosmin levels, pitaya will be a viable option for colouring foodstuffs. Although dragon fruit is being used to make a variety of value-added products, there is an apparent shortage of worldwide commercial promotion. Considering environmental safety and throughput capacity, it is also necessary to concentrate on mechanization in the production of value-added dragon fruit goods, as the manual process has been used for their preparation. By reducing production costs and human labour, mechanization will also help to improve the quality of final products. Peeling and seeding are examples of by-product processing that can boost profitability while producing new products for the food, cosmetic, and pharmaceutical sectors. In conclusion, efficient pitaya processing will have a significant positive impact on industrial and developing countries.

Reference

Jalgaonkar, K., Mahawar, M. K., Bibwe, B., & Kannaujia, P. (2022). Postharvest profile, processing and waste utilization of dragon fruit (Hylocereus spp.): A review. *Food Reviews International*, *38*(4), 733-759.

Kumar, B. A. B. L. U. (2021). *Study on Storage Stability of Dragon Fruit (Hylocereus Polyrhizus) Juice and Concentrate* (Doctoral dissertation, Master thesis., Junagadh Agricultural University, Junagadh).

Wakchaure, G. C., Choudhari, J. D., Kukde, R. B., & Reddy, K. S. (2023). Postharvest technology of dragon fruit. *Technical Bulletin*, (41), 45-106.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

THE ROLE OF PLASTIC TECHNOLOGIES IN ENHANCING POSTHARVEST MANAGEMENT

Article ID: AG-V04-I12-140

Ibrahim Muhammad Abdul[1*], Musa Kamilu[2], Oshadumo Dayo[3], Webnjoh Emile Kongvum[4] and Emmanuel Andrew[5]

[1, 2, 3] Outreach Research Department, Nigerian Stored Products Research Institute, Kano No 1 Batawa Close Off Hadejia Road

[1,4]Center for Dryland Agriculture, Department of Agricultural Economics and Extension, Bayero University Kano

[5]Department of Biochemistry, African Centre of Excellent in Population Health and Policy

*Corresponding Author Email ID: m.ib2010@yahoo.com

Abstract

To remain food secure, we need another green revolution. One of such is through the adoption of innovative agro practices, which will result in stretching our agro input resources manifold to increase agricultural productivity in both quantity and quality. Plasticulture applications are one of the most useful indirect agricultural inputs, which if hold will transform the Nigerian agricultural system, as it offers large number payback in water management, soil conservation, postharvest loss prevention and management among others. Due to the perishability of fruits and vegetables, lack of awareness and knowledge of postharvest handling techniques, and poor packaging materials, producers encounter 20-50% postharvest losses. However, the Nigerian Stored Products Research Institute have played a key role in the utilization of plastics, by developing a postharvest innovative solution in the areas of drying, short- and long-term storage, as well as handling and transportation of produce to mitigate the menace. It is recommended that government and key stakeholders in agricultural sectors should give more emphasis in the improvement of postharvest plastic technologies to make it efficient and cost-effective among value chain actors.

Keywords: Plastic; Plasticulture; Postharvest management; Institute

Introduction

The term plasticulture is a combination of two words, plastics, and agriculture, and is used in food production throughout the world. It is one of the latest developments in the field of agriculture, which is also recognized globally for improving crop production (Sood & Rawal, 2022). The National Agricultural Plastics Association (NAPA), which later became the American Society for Plasticulture (ASP) to encompass all aspects of plastic use in agriculture, was founded as a result of interest in this new technology. Plasticulture is simply the use of plastic in agriculture-related activities (Singh, Navnath, Malathi, and Singh, 2018). It is also defined as the practice of using plastic materials in agricultural applications, and according to the American Society for Plasticulture; it means "use of plastics in agriculture." Plastic comes in a wide variety of shapes and forms, based on the purpose for which it will be used.

Soil fumigation, irrigation, the packaging of farm products, and the protection of harvest from precipitation include Plasticulture. The history of plastics began in the year 1930, with the mass production of plastics. A type of plastic called polyethylene has been found beneficial for agriculture because it is more durable, flexible, and chemical resistant (Kasirajan & Ngouajio, 2012). Polyethylene was first used as a greenhouse construction material in the 1940s as an alternative to glass (Jensen, 2004). Plasticulture is one of the most significant indirect agricultural inputs that hold the potential to transform agriculture by ushering in the Second Green Revolution. Some of the indirect agricultural inputs to plasticulture are moisture conservation, controlled environment agriculture such as greenhouses, shade net houses, low tunnels, plant protection nets, Silage, Piping, and Planters production (Sood & Rawal, 2022). Farmers are using plasticulture technology to improve crop quality and increasing food production. Additionally, plastics have contributed hugely to providing innovative post-harvest solutions for increasing shelf-life and during collection, storage and transportation of horticultural crops such as fruits and vegetables (Rai, 2018), which in turn contribute towards the Agriculture-GDP. In general, the demand for plastics or plasticulture technology in increasing annually, and according to Food and Agriculture Organization experts, agricultural value chains use (12.5), crop production and livestock (10.2), fisheries and aquaculture (2.1) and forests (0.2) all of million tons of plastic per year.

Types of plastics used in plasticulture

The types of plastics used in plasticulture can be categorized into two.

A. Commodity plastics: are the majority of plastic types produced by the petrochemical industry. Following are some of the types of commodity plastic: Polyethylene (PE): Low Density PE (LDPE), High Density PE (HDPE), Linear Low-Density PE (LLDPE), Polypropylene (PP), Polyvinyl Chloride (PVC) and Polystyrene.

B. Engineering and Specialty plastics: are the types of plastics which provide enhanced mechanical and thermal properties when compared to commodity plastics. These plastics are used for very specific purposes in agriculture. Some of the examples of this kind of plastic are as follows: Styrene derivatives (PS/EPSS and SAN/ABS), Polycarbonate, Polymethyl methacrylate and Polyoxy methylene plastics (Mugnozo et al, 2011; Picuno, 2018; Akhter *et.al*, 2020).

Generally, LDPE (Low Density Polyethylene), PVC (Polyvinyl Chloride), PP (Polypropylene), LLDPE (Linear low- density polyethylene), HDPE (High Density Polyethylene) and PA (Polyamide) are typically used to make packaging materials for agriculture.

RESULTS AND DISCUSSION

The Role of Plastics/Plasticulture in Post-harvest activities

3.1 Overview

Due to the perishability of fruits and vegetables such as tomato, mango, pepper etc., lack of awareness and knowledge of postharvest handling techniques, and poor packaging, producers encounter 20-50% postharvest losses between the chain of farm and consumer (Kitinoja and Kader, 2015). Inefficient and bad packaging is one of the major factors of perishable crop damage. Plastic has enabled the designing of innovative packaging techniques which in turn has significantly reduced the wastage of fresh produce while being conveyed to markets and distribution centers from farmers or being stored. Reducing such post-harvest vegetable losses can significantly improve developing countries' access to food. Furthermore, fresh meats and harvested fish are stored and transported for many hours using plastic ice boxes, which helps prevents from spoilage.

The conventional methods of packaging products, especially fruits and vegetables in a jute bag and wooden crates have many disadvantages like untreated wood can easily become contaminated with fungi and bacteria, material may be too hard or rough for produce like soft fruits, need of disposal of the crates after use so not reusable and ultimately cost of such material is more. However, the advent of plastics has overcome these problems. Plastic packaging is very significant because plastics are flexible, lightweight with good tensile and tear strength, relatively low costs, hygienic, transparent, and easy to print and mould, reusable, and increase the shelf-life of products.

3.2 NSPRI in Plasticulture

The Nigeria Stored Products Research Institutes (NSPRI) whose mandate stipulates to carry out research into bulk storage problem of export commodities and local food crop of perishable crops including all roots and tuber crops, fruits and vegetables; durable crops including cereal grain, pulses, oil seeds; livestock products including milk, meat, fish and related products; tree crops including cocoa, kola, palm produce, coffee, cashew and sheanut etc. and to provide advisory services on post-harvest food handling and preservation has play a key role in utilization of plastics through the development of various postharvest technologies. Some of the very essential packaging, storing and drying entities made from or of plastic developed by NSPRI are listed below: (i) Ventilated plastic Crates, (ii) Nestable Ventilated Plastic crate(NVPC) (iii) Vegetable basket (iv) Hermetic storage system (Pics bag) **(v) Iced Fish box (vi) NSPRI Solar tent dryer(vii)Parabolic Solar Dryer (viii)** Composite packaging (CP) materials, fruits dryer etc., and which major areas of application in post-harvest management is targeted at drying of produce, short and long term storage, handling and transportation of produce. Below is the highlight:

3.2.1 NSPRI plastics technologies in drying of produce

Drying is simple method to preserve the agricultural produce for the long time. For drying of food crops and other by-products parabolic solar dryer (Fig. 1) and Paddy Solar dryer (Fig. 2), are used, which provides micro climatic condition for the protection of produce from water and dust. Parabolic Dryer is a framed structure covered with plastics film (transparent and translucent) made of polyethylene in which crops are dried under the partially or fully controlled environment.

Figure 1: Parabolic Solar Dryer

Figure 2: Paddy Solar dryer

The Solar technology has been considered an important in better space utilization and It helps to dry food crops such as cereals like maize, ground rice; legume like cowpea and by-products; fruits and vegetables such as tomato, peeled onion, other include Cassava, Yam, Plantain (unripe), Ginger roots, Powdered pap, Okra, Pepper, Leafy vegetables, Low fat fish (panla), Mango chips, Cassava chips etc.

Varghese, Rupesh, Jithu, Adithya, and Prajith (2021), depicted the advantages of solar plasticulture technology to include high drying rates and good maintenance of agricultural produces as compare to open sun drying.

3.2.2 NSPRI plastic technologies for handing and transportation of produces

Plasticulture technology is effectively used in transportation, and storage of agricultural produce. Plastic packaging gives microclimatic condition to the agricultural produce which maintains its quality and extends its shelf life. The NSPRI plastic technology gives opportunity to preserve the produce from short to long term storage. After harvesting produces are transferred from field to storage units or for packaging in which plastic crates are used.

Figure 3: Ventilated Plastic Crates

Figure 4: NSPRI Fish box and Improved NSPRI Iced Fish box.

Also, for transporting and handling of fish to long distances fish box are used which ease and prevent losses. Both help in easy movement of produce from one place to another and are made of High-Density Polyethylene (HDPE), which is a thermoplastic known for its durability.

3.2.3 NSPRI plastic technologies for short- and long-term storage

Purdue Improved Crop Storage (PICS) bag is a simple hermetic storage system that is used for the storage of durable crops e.g. cowpea, sorghum, maize, millet and consists of three layers of which two are made of high-density polyethylene liners fitted inside a woven polypropylene bag (Fig. 5). It is cost-effective and designed in such a way for easy storage of grains and seed without using synthetic pesticides to control insect pests.

Figure 5: Hermetic Storage System (Pics bag)

The PICS bags come in 50kg and 100kg sizes that can be use conveniently by grain handlers as well as household consumers for storages.

3.3 Other packaging materials/products

Other packaging materials like flexible plastic films, tray with over wrap, punnets, **leno bags,** net bag, foam sleeve, **foldable plastic box with cells, MAP of perishables shrink packaging, and Polytuneel dryer** and also used in storing, preserving and transporting of fresh as well as processed fruits **(**Ruchi, Singh and Saxena (2021), are develop and utilized worldwide.

Conclusion

Plastics are proving a blessed to the agriculture field. The Nigerian Stored Products Research Institute have played a key role in the utilization of plastics, by developing a postharvest innovative solution in the areas drying, short- and long-term storage, as well as handling and transportation of produces. With the application of plastic technologies in storage and transportation both food quality and quantity are maintained. Therefore, to remain food secure emphasis has to be given by government and other stakeholders to improve the plastic technologies to make it efficient and economic among the farmers to implement that in their field.

References

Akhter, A., Nabi, A., Ajaz. A. M, Sayed, A. I., Sultan, A., Javeed, I. and Tariq. A. Bhat. (2020). Plasticulture –A Key Step to Second Green Revolution. *Int.J.Curr.Microbiol.App.Sci* .Special Issue-11: 2299-2315

Kasirajan, S. and Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: a review. *Agron. Sustain. Dev.* 32, 501–529. https://doi.org/10.1007/s13593-011-0068-3

Kitinoja, L. and Kader, A.A. (2015). *Measuring Postharvest Losses of Fresh Fruits and Vegetables in Developing Countries.* The Postharvest Education Foundation Paper 15-02. http://postharvest.org/PEF_White_Paper_15-02_PHFVmeasurement.pdf

Mugnozza GS, Sica C, Russo G. (2011). Plastic Materials in European Agriculture: Actual use and perspectives. *Journal of Agriculture Engineering. 3:15-28.*

Picuno P. 2018. *Agriculture: Polymers in crop production*. Encyclopedia of polymer application.

Piringer, O. and Baner, A. (2000). *Plastic Packaging Materials for Food Barrier Function, MassTransport, Quality Assurance and Legislation*. Wiley-VCH, Weinheim, Germany. https://doi.org/10.1002/9783527613281

Pramod Rai. (2018). A concept note on implementation of plasticulture technology in Jharkhand. *HortFlora Research Spectrum Vol.7 No.1 pp.1-10 ref.24*

Ruchi, Singh, S. and Saxena, A. K. (2021). Plasticulture: Boon for Indian Horticulture Sector. *Indian Farmer Volume 8, Issue 01, Pp. 34-42* Available online at: www.indianfarmer.net ISSN: 2394-1227 (Online)

Samridhi ood and Vipul Kumar Rawal. (2022). Plasticulture: A new technology in agriculture production and post-harvest management. Just Agriculture.

Singh, R.K., Navnath, I.S., Malathi, A.N. and Singh, H. (2018). *Role of Plasticulture Technologies in Agriculture Production and Post-Harvest Management.* ICAR-Winter School.

Varghese, J., Rupesh, S., Jithu, A., Adithya, N. and Prajith, K. (2021). Design and analysis of a solar drier with a parabolic shaped dish type collector for drying peanut. International Conference on Innovations in Mechanical Sciences IOP Conf. Ser.: Mater. Sci. Eng. 1132 012046

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

AQUASILVICULTURE -AN APPROACH TO SUSTAINABLE COASTAL AQUACULTURE

Article ID: AG-VO4-I12-141

Kiruthisha K * and Cheryl Antony

TNJFU-Dr. MGR. Fisheries College and Research Institute, Ponneri,

Thiruvallur District, Tamil Nadu 601204, India

*Corresponding Author Email ID: kiruthishaqueen@gmail.com

Abstract

An inventive method of managing coastal resources, aquasilviculture combines aquaculture techniques with the preservation and sustainable use of mangrove forests. This approach creates a win-win link between economic activity and environmental conservation by combining the protection and rehabilitation of mangrove ecosystems with the production of aquatic species including fish, shrimp, and mollusks. Mangrove forests offer vital ecosystem functions such as water filtering, carbon sequestration, coastline protection, and habitat for marine life. However, because of irresponsible aquaculture practices, deforestation, and coastal development, mangroves have been fast disappearing. In order to overcome these obstacles, aquasilviculture encourages the peaceful cohabitation of mangrove conservation with aquaculture. Aquasilviculture offers a sustainable way to reconcile food production with environmental preservation as the demand for seafood throughout the world rises. This strategy helps to mitigate climate change, conserve biodiversity, and maintain long-term coastal sustainability by promoting a symbiotic interaction between aquaculture and mangrove ecosystems. Effective management techniques, regulatory support, community involvement, and ongoing monitoring to guarantee that ecological and economic goals are fulfilled are essential for aquasilviculture's success.

Keywords: Aquasilviculture, sustainable aquaculture, mangrove conservation, coastal ecosystem, biodiversity, climate change resilience, integrated farming, carbon sequestration**.**

Introduction

An inventive and sustainable aquaculture method called aquasilviculture combines fish farming with coastal ecosystem management and development, especially with reference to mangrove forests. This strategy fosters both environmental conservation and long-term livelihoods by balancing aquaculture activity with ecosystem restoration. The phrase is a combination of "aqua" (water) and "silviculture" (tree cultivation), emphasizing the simultaneous focus on aquatic farming and forestry management. As coastal habitats are under growing strain from deforestation, climate change, and unsustainable fishing methods, aquasilviculture presents a possible option to address both human and environmental needs. Fundamentally, aquasilviculture is the concurrent raising of aquatic animals, including crabs, shrimp, and fish, next to mangroves or other coastal vegetation. Mangroves are important ecosystems that operate as natural barriers against coastal erosion, lessen the effects of storms, and provide a variety of marine creatures with places to reproduce.

Aquasilviculture preserves the productive potential of these places while improving their ecological health through the integration of mangrove restoration into aquaculture. Mangroves encourage increased biodiversity and enhance water quality by capturing sediments and filtering contaminants. This results in a vibrant ecosystem that is ideal for wildlife and marine life.The ability of aquasilviculture to assist coastal people in maintaining sustainable means of subsistence is a major advantage. Conventional aquaculture methods frequently result in environmental deterioration, which can be detrimental to regional economies that rely on natural resources. However, because aquasilviculture offers several revenue streams, it promotes resource conservation. Aquasilvicultural communities can cultivate fish or crustaceans and profit from mangrove-related activities like timber harvesting and honey extraction. This multifaceted strategy preserves the environmental health while assisting in ensuring food security and economic resilience.

Species used for Aquasilviculture

The choice of species in aquasilviculture is essential to the long-term profitability of the industry. The species that are cultivated there usually grow well in brackish water and are a beneficial addition to the natural mangrove ecosystems. The milkfish (*Chanos chanos*), which is a popular choice because of its resilience to varying salinities and its relevance as a food fish in many coastal regions, is one of the principal species utilized in aquasilviculture. The mud crab

(*Scylla serrata*), sometimes called the mangrove crab, is another species that is raised extensively. It lives in the tidal zones between mangroves and is an excellent candidate for fattening.

Shrimp species, particularly black tiger shrimp (*Penaeus monodon*) and whiteleg shrimp (*Litopenaeus vannamei*), are popular in aquaculture because to their high market value and ability to incorporate shrimp farms into mangrove habitats. In addition to fish and shrimp, tilapia (*Oreochromis* spp.) is frequently cultivated because to its adaptability to changing water conditions and its value as a low-cost protein source. Finally, sea cucumbers (*Holothuria scabra*) are increasingly used in aquaculture systems due to their potential to improve nutrient cycling and ecosystem health.These species not only aid coastal towns economically, but they also contribute to the aquaculture system's overall ecological balance by thriving in mangrove environment. Their compatibility with mangroves guarantees that the aquatic and terrestrial components of the ecosystem are preserved and nurtured.

Synergistic effect of Aquasilviculture

The synergistic effect of aquasilviculture generates a variety of benefits from the interplay of aquaculture and mangrove ecosystems, resulting in more sustainable and productive outputs. Environmentally, mangroves operate as natural filters, increasing water quality by trapping sediments and decreasing pollutants, which benefits the health and growth of farmed species such as fish, shrimp, and crabs. Mangrove roots also help to support the soil, which prevents coastal erosion and protects aquaculture ponds from storms and tides. This synergy not only protects the environment but also increases biodiversity, since mangroves provide vital habitats and breeding grounds for both farmed and wild species, resulting in healthier ecosystems and lowering the risk of disease outbreak.

Aquasilviculture boosts aquaculture businesses' productivity financially. Improved water quality and ecological balance lead to higher growth rates and survival of farmed species, while the integration with mangroves allows communities to diversify their income through the harvesting of other mangrove-based resources such as wood, honey, and eco-tourism opportunities. This generates several revenue streams, which lowers financial risks. Furthermore, long-term ecosystem support for aquaculture and other industries is ensured by the sustainable use of coastal resources.

Socially, aquasilviculture improves food security by maintaining the mangrove ecosystems that local communities depend on for resources and protection while guaranteeing a consistent supply of wholesome, high-protein aquatic products. Aquasilviculture creates resilient, self-sustaining communities that are better able to manage environmental difficulties by fostering a healthy balance between people and nature.

Mangrove - Aquaculture integration

Mangrove-aquaculture integration, also known as **silvofisheries** or integrated mangrove aquaculture (IMA), entails cultivating aquatic animals (such as fish, shrimp, or crabs) alongside mangrove forests. This strategy delivers mutual benefits by increasing aquaculture productivity and mangrove ecosystem services. In IMA, mangroves are either conserved or replanted around aquaculture ponds, or incorporated directly into the architecture of farming systems, such as putting them in rows within ponds or along embankments.

The presence of mangroves in these systems enhances water quality because their roots filter pollutants and trap sediments, minimizing the need for artificial water treatment in aquaculture. Furthermore, mangroves provide habitat and breeding grounds for a variety of species, promoting both biodiversity and the expansion of farmed species such as shrimp and fish. This integration also helps coastal protection by stabilizing soils and minimizing erosion, while contributing to carbon sequestration and combating climate change.

Importance of Aquasilviculture

Aquasilviculture is very important for creating environmental sustainability, economic resilience, and social well-being in coastal communities. The practice of merging aquaculture with mangrove conservation guarantees the improvement of ecosystems and biodiversity. Mangroves serve as organic biofilters, capturing sediments and filtering pollutants to enhance the quality of water for farmed species such as fish and shrimp. Additionally, they offer crucial coastal protection by preventing soil erosion and acting as barriers against extreme weather events, which are becoming more frequent as a result of climate change. Moreover, mangroves are essential for carbon sequestration, which absorbs and stores atmospheric carbon to lessen the consequences of climate change.

Aquasilviculture is gaining popularity for its holistic benefits, which combine ecological conservation with economical gains. One of its primary assets is mangrove conservation, which not only protects coastal areas from harsh weather occurrences but also serves as vital nurseries for a variety of marine species, benefiting fisheries. The symbiotic interaction between aquaculture and mangroves enhances water quality by filtering out surplus nutrients and pollutants from fish farming activities, hence reducing ecosystem damage.

Benefits of Aquasilviculture

Aquasilviculture provides various benefits by combining aquaculture and mangrove forest conservation. One of its primary benefits is environmental sustainability, as it promotes the preservation of mangroves, which serve as natural barriers against coastal erosion, hurricanes, and rising sea levels while also increasing biodiversity. The technique improves water quality by using mangroves as natural filters, lowering nutrient runoff from aquaculture activities. Economically, it provides a broad and sustainable source of income for coastal communities by mixing fish farming with forest products such as wood, honey, and medicinal plants. Diversification decreases reliance on a single source of income while also improving food security. Furthermore, aquasilviculture improves ecological balance by minimizing the need for synthetic inputs such as chemical feeds and fertilizers, making it cost-effective and environmentally friendly.

Challenges of Aquasilviculture

Aquasilviculture provides numerous benefits, but it also has drawbacks and difficulties. The difficulty of maintaining the equilibrium between aquaculture and mangrove ecosystems is a significant disadvantage. It can be challenging to maintain healthy mangrove forests while maintaining ideal conditions for aquaculture since shifts in temperature, salinity, and nutrient levels can have an impact on both the mangroves and aquatic organisms. Furthermore, small-scale farmers may find it difficult to set up an aquasilviculture system because it takes a lot of time, effort, and resources. Because mangrove ecosystems are vulnerable to human activity, poor management practices can cause ecosystem degradation, which can have an impact on aquaculture output and forest health. Furthermore, the need for ongoing monitoring and technical expertise to maintain the delicate balance between these interconnected systems can be a challenge for communities with limited access to training and resources. These factors can make the widespread adoption of aquasilviculture difficult in some regions.

Conclusion

Aquasilviculture is a viable and sustainable strategy to coastal resource management that combines the economic benefits of aquaculture with the environmental benefits of mangrove forest conservation. This method restores degraded ecosystems, enhances biodiversity, and improves coastal areas' resistance to the effects of climate change by promoting a symbiotic interaction between fish and shrimp farming and mangrove conservation. Organic interactions between mangroves and aquatic animals help to lessen aquaculture's environmental footprint, resulting in more sustainable food production systems. Furthermore, aquasilviculture improves coastal people' livelihoods by diversifying income streams and mitigating the dangers associated with traditional farming practices. It provides a feasible solution to the rising worldwide demand for seafood while promoting the long-term health and stability of coastal environments.

References

Fitzgerald, W. J. (2002). Silvofisheries: Integrated mangrove forest aquaculture systems. *Ecological Aquaculture: The Evolution of the Blue Revolution. Blackwell Science Ltd, Oxford, UK*, 161-262.

Kabir, M. H., & Abdul Baten, M. (2019). Community mangrove aqua-silviculture (CMAS Culture): An innovation and climate resilient practice by the Sundarbans mangrove forest dependent rural communities of Bangladesh. *International Journal of Environment and Climate Change*, 1-16.

Susitharan, V., & Sindhu, C. (2021). Aquasilviculture: a novel safeguard for mangrove ecosystem. *Justagric*, *1*, 1-8.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

A REVIEW ON NUTRACEUTICAL POTENTIAL OF ASH GOURD

Article ID: AG-VO4-I12-142

Jyotirmayee Sahoo[1]

PhD research scholar, Food and Nutrition, College of Community Science,

Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar, 848125 India

*Corresponding Author Email ID: ahoojyotirmayee355@gmail.com

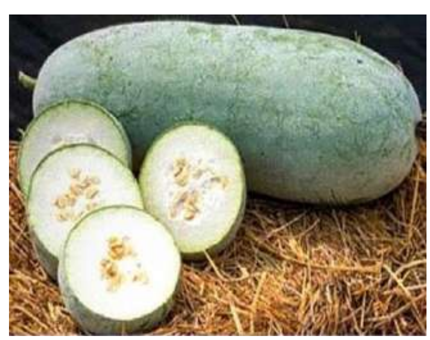
Abstract

Ash gourd [*Benincasa hispida* (Thunb.)] is a widely consumed vegetable across various countries. In recent times, vegetables are increasingly valued not only for their nutritional content but also for their functional and health-promoting properties. The entire ash gourd plant, including its fruit peel, flowers, seeds, and leaves, is commonly utilized. The fruit exhibits a range of biochemical activities, such as antioxidant, anti-inflammatory, anti-angiogenic, detoxifying, and therapeutic effects for managing several health conditions. Additionally, it contains vital minerals like calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn) and selenium (Se). This review explores the applications of ash gourd in both nutraceutical and medicine.

Keywords: Ash Gourd, Nutraceutical Source, Health Benefits, Ayurvedic Effect, Value Additions, Side effects

Introduction

Ash gourd (*Benincasa hispida* (Thunb.) Cogn.), also known as hairy melon, wax gourd, winter melon, ash pumpkin, or “Kushmanda” in Ayurveda, is a versatile plant valued for its nutritional and medicinal properties. It is the only species in the *Benincasa* genus, with immature fruits covered in fine hairs that vanish upon ripening and a distinctive white powdery coating on mature gourds, giving rise to the name “Ash Gourd.” This warm-



season cucurbit is cultivated for its succulent fruits, used in cooking, confectionery, and Ayurvedic medicine, while the entire plant—including the peel, flowers, seeds, and leaves—has applications. Known for its antioxidant, anti-inflammatory, detoxifying, and therapeutic benefits, ash gourd has been utilized in traditional Chinese and Ayurvedic medicine for centuries, though limited benefits are scientifically proven. Low in calories, rich in water and fiber and packed with essential nutrients, it supports metabolic health, offers a cooling effect and promotes heart health, making it a valuable addition to both diets and traditional remedies (Pradhan *et al*., 2020).

Nutritional Value of Ash Gourd

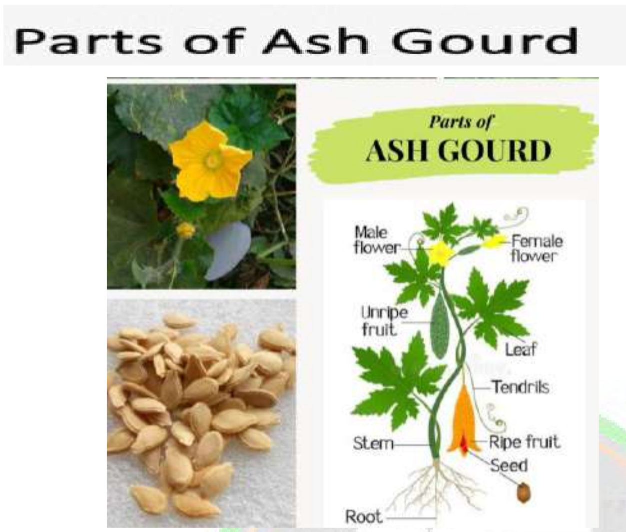
Vitamins and minerals are essential nutrients required for the body to function efficiently, and they can be obtained through regular dietary intake. Among various countries, Malaysia's Kundur fruit stands out for its high riboflavin and vitamin C content, providing 68.00 mg and 0.31 mg per 100 g of edible portion, respectively. Thiamin is the least abundant vitamin in the fruit, ranging from 0.02 to 0.04 mg per 100 g. Potassium (K) and calcium (Ca) are the most prevalent minerals in the fruit, with levels between 77–131 mg and 5–23 mg per 100 g of edible portion, respectively, while iron (Fe) is the least present. Potassium and calcium are particularly important for maintaining the electrolyte balance of body fluids and helping to alkalinize the body (Aggarwal *et al*., 2023).

Table 1: Nutritional value of Ash Guard

Vitamins	Minerals	Macro Nutrients
Vitamin A-9.8%	Calcium-5.1%	Carbohydrate-12.5g
Vitamin B_6-11.33%	Magnesium-6.7%	Fat-3.9g
Vitamin B_3-0.5%	Phosphorus-5%	Dietary fibre-0.6g
Vitamin C- 30.5%	Zinc-7.2%	Protein-2g
Vitamin E-1.1%	Iron-5.7%	Sodium-33 mg
	Magnesium-12.5%	Potassium- 359.1mg
	Iodine-5.9%	

Properties of Ash Gourd

The fruit is a large, fleshy pepo characterized by a thin epidermal skin, a juicy and fleshy mesocarp, and a thick, swollen placenta. It is tricarpellary, syncarpous, and exhibits peripheral placentation. Traditionally, the fruit has been used to address various ailments, including renal diseases, jaundice, dyspepsia, fever, and menstrual disorders. Methanol extracts of the fruit have demonstrated anti-ulcer, anti-inflammatory, antihistaminic, and antidepressant properties. Additionally, the fruits of ash guard have been traditionally employed in the treatment of epilepsy and other neurological disorders [https://ijapr.in/index.php/ijapr/article/view/2215/1508



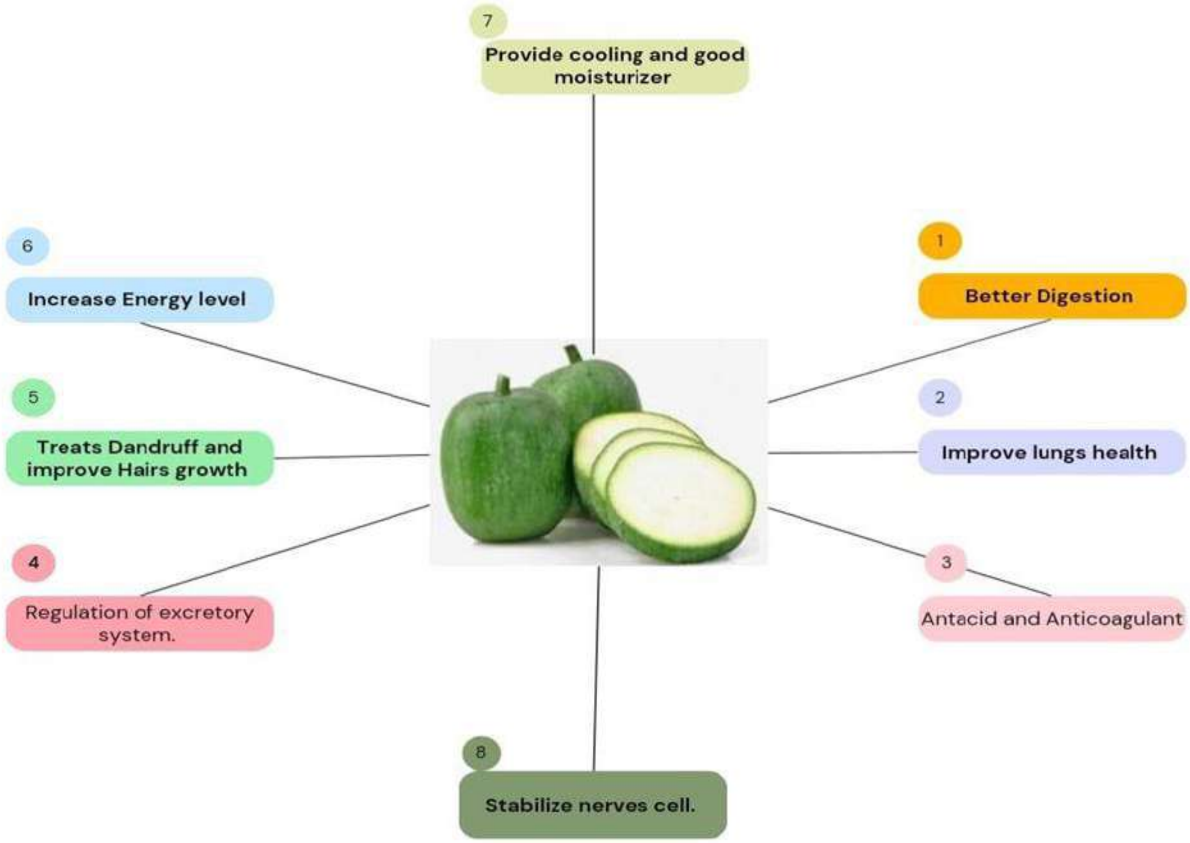
Health Benefits of Ash Gourd

Ash gourds have a connection in aiding weight loss. Many consume it in its liquid form as a detox juice. Some of the reasons for this are:

Ash gourd is often associated with weight loss and is commonly consumed as a detox juice. This is largely due to its high fiber content, which slows digestion and helps maintain a feeling of fullness for extended periods, even in small portions. Additionally, ash gourd is extremely low in calories, making it suitable for consumption in larger quantities without contributing to excessive caloric intake. Its negligible fat content further enhances its appeal as a healthy snack option for those aiming to manage their weight.

Vitamin B2 in ash gourd boosts energy levels, supporting workouts and muscular activities. The potassium content acts as a natural diuretic, reducing water retention and bloating. Since stress eating is a common contributor to weight gain, the riboflavin in ash gourd helps regulate stress hormones and also plays a role in managing thyroid hormone levels.

Ash gourd has a natural cooling effect on the body and is rich in soluble fiber, making it highly beneficial for gut health. Its high soluble fiber content supports the growth of beneficial gut bacteria, helps relieve indigestion, constipation, and hemorrhoids and promotes overall colon health. Additionally, ash gourd is effective in managing stomach-related issues such as hyperacidity, dyspepsia and ulcers (Pradhan *et al*., 2020).



Ayurvedic Effect of Ash guard:

Ash gourd holds significant importance in Ayurveda, where it is referred to as "Kushmanda". It can be utilized in both its ripe and unripe forms. Various parts of the plant, including its flowers, leaves, bark, roots, stems and fruits, are used for therapeutic purposes. Kushmanda offers many benefits like Antioxidant activity, Anti-inflammatory analgesic activity, Antimicrobial activity, Antiulcer activity, Antipyretic, Antidepressant activity, Anti-convulsion activity, Histamine activity and Anorectic activity (Sivarajan *et al*., 1994)

Ash gourd is also widely used in cooking, featuring in dishes like vegetables, salads, chips and sweets. In the form of juice, paste, powder and other preparations, it is employed to treat conditions such as piles, internal bleeding, anemia, cough, and heart disease. *Kushmanda* offers both therapeutic and preventive benefits. To promote the traditional knowledge associated with this plant, systematic studies are needed to evaluate its nutritional properties. Additionally, further research in Ayurveda is essential to enhance the understanding of *Kushmanda*, also known as *Benincasa hispida*.

Gulkand, a tonic in Ayurvedic medicine, helps reduce body heat and pacify pitta dosha. It is effective in alleviating eye inflammation and redness, strengthening teeth and gums, and treating acidity. Gulkand also has a cooling effect, relieving symptoms such as lethargy, fatigue, itching, pain, and burning sensations in the palms and soles. Furthermore, it acts as a powerful antioxidant and revitalizer (Grover *et al*., 2001)

Value Additions of Ash Gourd

Ash gourd, also known as *Benincasa hispida*, is widely used to prepare various sweets, which are especially popular in many parts of India. Among the famous value-added products made from ash gourd are *bari* (nuggets) and *petha* (a sweet candy). *Badi*, one of the most popular sun-dried items, can be eaten as is, deep-fried, or incorporated into different dishes.

Petha is a well-known dessert in India, particularly in the western regions of Uttar Pradesh and is believed to have originated in Agra. This soft, chewy, candy-like sweet can be enjoyed either dry or soaked in sugar syrup (*chashni*). It is made by cooking the fruit pulp in water with sugar syrup and flavoring agents. The versatility of *petha* is reflected in its different forms, such as crystallized or glazed varieties, where cooked ash gourd is dipped into concentrated sugar solutions with added flavors and colors to enhance its taste and visual appeal. The preparation and serving of these sweets can be tailored to suit individual preferences, showcasing their delicacy and adaptability (Pradhan *et al*., 2020).

Side Effects of Ash Gourd

Various toxicological studies conducted on rats have indicated that ash gourd is generally safe, with even high doses of 10 g/kg causing no mortality. However, extracts of ash gourd in chloroform have shown significant morbidity in rats. Excessive consumption of ash gourd juice or prolonged use may lead to an accumulation of phlegm due to its waxy nature, which can be particularly harmful to individuals with asthma or bronchitis. Additionally, while ash gourd is rich in minerals, long-term consumption could potentially result in toxic levels of metallic substances accumulating in the body [https://pharmeasy-in.cdn.ampproject.org/v/s/pharmeasy.in/blog/ayurveda-uses-benefits-side-effects-ofash-gourd].

Conclusion

Ash gourd juice is an excellent detoxifier and is best consumed in the morning. It effectively absorbs toxins, bacteria, and impurities that accumulate in the body throughout the day and helps flush out waste. The juice is rich in calcium, iron, phosphorus, and vitamin C. Before juicing, the seeds of the ash gourd, which contain pale yellow oil, should be removed. This juice is especially beneficial for individuals with constipation as it soothes the digestive tract. A combination of *safed petha*, coconut milk, lime juice, and amla juice is also effective. For those with gastroenteric worms, a mixture of coconut milk and ash gourd juice can provide relief. Additionally, it supports tissue development. Research in rats has shown that ash gourd juice can alleviate morphine withdrawal symptoms and aid in opioid addiction. The juice is also noted for its anti-ulcer, antidepressant, anti-inflammatory, and antibacterial properties. It plays a significant role in suppressing opioid or morphine addiction by directly influencing the central nervous system and acts as a gastro-protective agent. In Ayurveda, it is valued for its wide-ranging health benefits. Ash gourd thrives in well-drained loam and sandy soils in warm, temperate climates and is frost-resistant. It is typically grown in riverbeds or furrows and requires regular watering throughout the growing season.

References

Pradhan, K., Nandi, A., Tripathy, B. and Rout, S. (2020). Nutrient Uptake Of Ash Gourd [Benincasa Hispida (Thunb.)Cogn.]Germplasm. *Journal of Plant Development Sciences*. 12(6): 361-364.

Aggarwal, A., Sharma, L., Sharma, D., Dhobale, S., Deshmukh, N., Barde, L and Tare, H. (2023). Nutritional Significance of Benincasa hispida. *International Journal of Pharmaceutical Quality Assurance.* 14(2):410-415.

https://ijapr.in/index.php/ijapr/article/view/2215/1508

Sivarajan, V.V. and Balachandran, I. (1994), "Ayurvedic drugs and their plant sources", 1st ed.,Oxford and IBH Publishing, New Delhi.

Grover, J.K., Adiga, G., Vats, V and Rathi, S.S. 2001. Extracts of Benincasa hispida prevent development of experimental ulcers. *Journal of ethnopharmacology*. 78(2-3):159-64.

https://pharmeasy-in.cdn.ampproject.org/v/s/pharmeasy.in/blog/ayurveda-uses-benefits-side-effects-ofash-gourd-

Volume: 04 Issue No: 12

PHASES OF SEED DEVELOPMENT

Article ID: AG-V04-I12-143

S. Manju Devi[1*] and P.V. Soundhiriyan[2]

[1]Department of Genetics and Plant Breeding, TNAU, Coimbatore

[2] Department of Pathology, TNAU, Coimbatore,Tamil Nadu, India

*Corresponding Author Email ID: manjuagri95@gmail.com

Abstract

The seed habit is the most complex and successful method of sexual reproduction in vascular plants. Seed contain the genetic wisdom of the past and the potential for its perpetuation in the future. Seed development is central to the reproductive strategy of angiosperms. The seed represents the unit of reproduction of flowering plants, capable of developing into another plant.

Keywords: Seed, microsporangium, megasporangium, gametophyte, endosperm, maturation.

Introduction

In gymnosperms and angiosperms, seeds arise from ovules, which consist of a stalk bearing the nucellus. The nucellus is covered by integuments, which are diploid maternal tissues—one in gymnosperms and two in angiosperms. Developmentally, an ovule is an immature seed precursor, while morphologically and evolutionarily, it is a megasporangium enclosed by integuments. These integuments later form the testa (seed coat), where the outer layers usually die to form a protective covering, and the inner layers may remain alive in mature seeds.

Within the nucellus, a megaspore develops into a haploid megagametophyte (female gametophyte). The mature gymnosperm megagametophyte is multicellular and typically forms several archegonia, each producing one egg. In contrast, the angiosperm megagametophyte, known as the embryo sac, is seven-celled and eight-nucleate in most species, following the Polygonum-type developmental pattern.

STAGES OF SEED DEVELOPMENT

1. Seed formation (Formation of male and female gametophyte)
2. Development of seed
3. Maturation of seed

Formation of male and female gametophyte

The male gametophyte develops and reaches maturity in an immature anther. Pollen development occurs in a structure called the microsporangium, where bi-lobed microsporangia function as pollen sacs. Inside these sacs, microspore mother cells undergo meiosis to produce four microspores, each of which eventually develops into a pollen grain. A layer of cells known as the tapetum nourishes the growing microspores and contributes essential components to the pollen wall. Mature pollen grains consist of two cells: a generative cell and a pollen tube cell. The generative cell resides inside the larger pollen tube cell. During germination, the pollen tube cell grows into a pollen tube that allows the generative cell to travel toward the ovary. While moving through the pollen tube, the generative cell divides to produce two male gametes. Once the microsporangia reach maturity, they rupture, releasing pollen grains from the anther.

Pollen grains are protected by two layers: the thicker outer layer called the exine and the inner layer known as the intine. The exine is reinforced with sporopollenin, a waterproof and durable substance produced by tapetal cells. Sporopollenin enables pollen to withstand unfavourable environmental conditions and facilitates its transport via wind, water, or biological agents without sustaining damage.

Female Gametophyte (Embryo Sac)

The development of the female gametophyte occurs in two key phases. In the first phase, known as megasporogenesis, a single cell within the diploid megasporangium undergoes meiosis to produce four megaspores, of which only one survives. In the second phase, megagametogenesis, the surviving haploid megaspore undergoes mitotic divisions to form an eight-nucleate, seven-celled female gametophyte, also called the megagametophyte or embryo sac. Within this structure, the polar nuclei migrate to the center and fuse to form a diploid central cell, which later combines with a sperm cell to create the triploid endosperm. At the opposite end of the micropyle, three nuclei form the antipodal cells, which eventually degenerate. The nucleus nearer to the micropyle becomes the egg cell, or female gamete, while the two adjacent nuclei develop into synergid cells. These synergid cells guide the pollen tube for fertilization and disintegrate afterward. Following fertilization, the diploid zygote develops into the embryo, and the fertilized ovule forms the seeds other tissues.

The megasporangium, and later the embryo sac, is protected by a double-layered integument. After fertilization, the integument develops into the seed coat, ensuring the seed's protection. The ovule wall eventually becomes part of the fruit. While the integuments safeguard the megasporangium, they do not entirely enclose it, leaving a small opening called the micropyle. This micropyle allows the pollen tube to enter the female gametophyte and facilitate fertilization.

Development of seed

1. Embryo development
2. Endosperm development

1. Embryo development

After fertilization, the single-celled zygote gradually develops into the embryo. The main structure of the embryo include the apical meristem, hypocotyl, cotyledons, root and shoot meristems, as well as a radial organization consisting of the epidermis, conductive tissues, and vascular layers. The first division of the zygote is asymmetric, creating a smaller apical cell and a larger basal cell. The apical cell gives rise to most of the embryo, while the basal cell contributes to parts of the root and forms the suspensor. As the embryo progresses from the globular stage to the heart stage, the cotyledons' fate and number are determined, leading to the formation of two cotyledons in dicot embryos.

2. Endosperm formation

The endosperm plays a crucial role in the development of the fertilized embryo. It forms the surrounding tissue that nourishes the growing embryo. Serving as the primary storage tissue, its main function is to supply starch and other essential nutrients to support the embryo's growth. Based on the mode of development the endosperms are classified as nuclear endosperms, cellular endosperms and helobial endosperms.

Maturation of seed

Seed maturation is a critical stage in seed development where embryo growth stops, storage reserves accumulate, the protective seed coat forms, and desiccation tolerance is established, ultimately resulting in seed dormancy..

Conclusion

Seed development and the determination of its final size involve a multi-step process regulated by a complex network. In addition to serving as a valuable model for fundamental research, seed size is a significant trait for farmers and the food, feed, and bio-based industries, as seeds form the foundation of these economies. A key challenge during seed maturation is understanding the interactions among the various regulatory networks.

References

Devic, M., & Roscoe, T. (2016). Seed maturation: Simplification of control networks in plants. Plant Science, 252, 335-346.

Nonogaki, H. (2006). Seed germination—the biochemical and molecular mechanisms. Breeding Science, 56(2), 93-105.

Shu, K., Liu, X. D., Xie, Q., & He, Z. H. (2016). Two faces of one seed: hormonal regulation of dormancy and germination. Molecular plant, 9(1), 34-45.

Wobus, U., & Weber, H. (1999). Seed maturation: genetic programmes and control signals. Current opinion in plant biology, 2(1), 33-38.

Volume: 04 Issue No: 12

THE IMPORTANCE OF APICULTURE: WHY BEEKEEPING MATTER

Article ID: AG-V04-I12-144

***Dr.I.Venkata Reddy[1,] Dr.K.Atchuta Raju[2], Dr. N.Rajasekhar[1], Dr.T.Jeswanth Reddy**

[1] SMS (Extension), KVK, Garikapadu, NTR District, Andhra Pradesh

[2]Programme Coordinator, KVK, Garikapadu, NTR District, Andhra Pradesh, India

[3]SMS (Programme Coordinator), KVK, Garikapadu, NTR District, Andhra Pradesh, India

[4]SMS (Veterinary Science), KVK, Garikapadu, NTR District, Andhra Pradesh, India

*Corresponding Author Email ID: ivrextedu18@gmail.Com

Abstract

Apiculture, or beekeeping, is an ancient practice that plays a vital role in modern agriculture and ecosystem health. This article delves into the world of beekeeping, exploring its history, benefits, and challenges. From the basics of hive management to the importance of bee health and disease management, this article provides an in-depth look at the art and science of apiculture. With a focus on sustainability and environmental stewardship, this article highlights the crucial role that beekeeping plays in maintaining ecosystem balance and promoting food security. Whether you're a seasoned beekeeper or just starting out, this article provides valuable insights and practical tips for anyone interested in the fascinating world of apiculture.

Keywords: apiculture, beekeeping, hive management, bee health, sustainability, environmental stewardship, ecosystem balance, food security.

Introduction

Apiculture, or beekeeping, is the practice of maintaining and caring for colonies of honey bees and other bees for their honey, beeswax, and other products. With a history dating back over 15,000 years, apiculture is an ancient and revered art that has played a vital role in human society, providing not only food and income but also a deeper connection to nature. From the intricate social hierarchies of the hive to the incredible industry and adaptability of these tiny creatures, bees are fascinating and highly beneficial insects. As pollinators, they are responsible for the reproduction of countless plant species, including many of our most important food crops. In fact, it's estimated that one-third of all the food we eat is directly or indirectly dependent on bee pollination.

Despite their importance, bee populations are facing numerous threats, including habitat loss, pesticide use, climate change, and disease. As a result, apiculture has become an increasingly important practice, not only for the production of honey and other bee products but also for the conservation and sustainability of bee populations. In this article, we'll delve into the world of apiculture, exploring its history, benefits, and challenges. We'll also examine the latest research and innovations in beekeeping, from integrated pest management to urban beekeeping. Whether you're a seasoned beekeeper or just starting out, this article aims to provide a comprehensive introduction to the fascinating world of apiculture.

History of apiculture in India

Apiculture, or beekeeping, has a rich history in India, dating back to ancient times. The practice has been mentioned in Hindu scriptures like the Rig Veda and Atharva Veda, as well as Buddhist scriptures. In fact, rock paintings from the Mesolithic era in Madhya Pradesh depict honey collection activities.

Modern Apiculture in India

Today, India is home to five commercially important species of bees, including the Indian honey bee (Apis cerana indica) and the European honey bee (Apis mellifera). The country produces around 70,000 metric tons of honey annually, with 70% coming from informal segments.

Beekeeping Practices

Beekeeping in India is promoted through various rural developmental programs, and many organizations, like the Khadi and Village Industries Commission (KVIC), provide training and support to beekeepers. Modern beekeeping practices have been adopted in many parts of the country, with a focus on scientific methods and sustainable practices.

Challenges and Opportunities

Despite the growth of apiculture in India, there are challenges to be addressed, such as the impact of climate change, pests, and diseases on bee populations. However, there are also opportunities for innovation and entrepreneurship in the sector, particularly in areas like honey processing and marketing.

Importance of Apiculture

1. Honey production: Bees produce honey, a natural sweetener with medicinal properties.

2. Pollination: Bees pollinate crops, contributing to food security and ecosystem health.

3. Beeswax production: Beeswax is used in candle-making, cosmetics, and pharmaceuticals.

4. Biodiversity conservation: Beekeeping helps maintain bee populations, supporting biodiversity.

Types of Beekeeping

1. Hobby beekeeping: Recreational beekeeping for personal enjoyment.

2. Commercial beekeeping: Large-scale beekeeping for honey and beeswax production.

3. Sustainable beekeeping: Emphasizes environmental sustainability and bee health.

Bee Species

1. **Western honey** bee (*Apis mellifera*): Most common species kept for honey production.

2. Italian honey bee (*Apis mellifera ligustica*): Known for high honey production.

3. Carniolan honey bee (*Apis mellifera carnica*): Popular for its gentleness and productivity.

Beekeeping Equipment

1. Beehive: A structure to house the bee colony.

2. Protective clothing: Veil, gloves, and suit to protect the beekeeper from stings.

3. Smoker: A device to calm bees by producing smoke.

4. Hive tool: A small device to open the hive and inspect the colony.

Challenges in Apiculture

1. Colony collapse disorder (CCD): A phenomenon where worker bees disappear or die.

2. Varroa mite infestations: A parasite that can weaken bee colonies.

3. Pesticide use: Exposure to pesticides can harm bee health.

4. Climate change: Changes in temperature and precipitation patterns can impact bee populations.

Best Practices in Apiculture

1. Regular inspections: Monitor the colony's health and detect issues early.

2. Proper hive management: Ensure the hive is well-ventilated and free of pests.

3. Integrated pest management (IPM): Use a combination of methods to manage pests and diseases.

4. Record keeping: Keep accurate records of hive inspections, treatments, and harvests.


Protective clothing and explaining about different activities of Bees

BEE FLORA

Bee flora, or bee-friendly plants, are essential for apiculture as they provide nectar, pollen, and shelter for honey bees. Here are some different bee flora suitable for apiculture:

Nectar-Rich Plants

1. Sunflower (*Helianthus annuus*): Rich in nectar and pollen.

2. Zinnia (*Zinnia spp*.): Attracts bees with its vibrant flowers.

3. Cosmos (*Cosmos bipinnatus*): Produces an abundance of nectar-rich flowers.

4. Lavender (*Lavandula spp*.): A low-maintenance, nectar-rich plant.

5. Rosemary (*Rosmarinus officinalis*): A fragrant, nectar-rich herb.

Pollen-Rich Plants

1. **Apple (Malus domestica):** A rich source of pollen for bees.

2. Cherry (Prunus avium): Produces an abundance of pollen.

3. Almond (Prunus dulcis): A valuable source of pollen for bees.

4. Pumpkin (*Cucurbita pepo*): Rich in pollen and nectar.

5. Squash (*Cucurbita spp*.): Produces an abundance of pollen.

Bee-Friendly Trees

1. Eucalyptus (*Eucalyptus spp*.): A rich source of nectar and pollen.

2. Acacia (*Acacia spp*.): Produces an abundance of nectar and pollen.

3. Orange (*Citrus sinensis*): A valuable source of nectar and pollen.

4. Lemon (*Citrus limon*): Rich in nectar and pollen.

5. Avocado (*Persea americana*): Produces an abundance of nectar and pollen.

Bee-Friendly Herbs

***1. Bee Balm (Monarda* didyma):** Attracts bees with its fragrant flowers.

2. Mint (*Mentha spp*.): A hardy, bee-friendly herb.

3. Oregano (Origanum vulgare): Rich in nectar and pollen.

4. Thyme (Thymus spp.*):* *A low-maintenance, bee-friendly herb.*

***5. Sage (Salvia* officinalis):** Produces an abundance of nectar and pollen.

Regional Considerations

1. Tropical regions: Plant tropical flowers like Hibiscus, Plumeria, and Heliconia.

2. Temperate regions: Plant temperate flowers like Sunflowers, Zinnias, and Cosmos.

3. Desert regions: Plant drought-tolerant flowers like Lavender, Rosemary, and Eucalyptus.

List of Equipment Used In Apiculture (Beekeeping):

Protective Clothing

1. Beekeeping suit: A full-body suit to protect against stings.

2. Veil: A mesh or fabric veil to protect the face and neck.

3. Gloves: Long, thick gloves to protect the hands.

Hive Equipment

1. Beehive: A structure to house the bee colony (e.g., Langstroth, Top-bar, Warre).

2. Hive stand: A platform to elevate the hive off the ground.

3. Hive tool: A small device to open the hive and inspect the colony.

Smokers and Fuel

1. Smoker: A device to produce smoke, calming the bees.

2. Smoker fuel: Materials like newspaper, kindling, or specialized fuels.

Hive Inspection and Management

1. Frame grip: A tool to handle frames without crushing bees.

2. Frame lifter: A device to lift frames out of the hive.

3. Honey extractor: A device to extract honey from frames.

4. Queen excluder: A mesh or perforated sheet to separate the queen from the rest of the colony.

Pest and Disease Management

1. Medicine dropper: A tool to administer medications to the bees.

2. Mite brush: A soft-bristled brush to gently remove mites from bees.

3. Varroa mite treatment: Chemical or natural treatments to control varroa mite infestations.

Honey Harvesting and Processing

1. Honey spinner: A device to extract honey from frames.

2. Honey filter: A device to filter honey for clarity and purity.

3. Honey bottler: A device to fill bottles with honey.

Miscellaneous

1. Bee brush: A soft-bristled brush to gently remove bees from surfaces.

2. Bee escape: A device to clear bees from supers before harvesting honey.

3. Hive record book: A notebook to record hive inspections, treatments, and harvests.

Beehives produce various valuable bi-products beyond honey, including:

1. Beeswax:- Used in candle-making, cosmetics, polish, and food wrapping.

2. Propolis:-A resinous mixture used in natural medicine, cosmetics, and wood finishes.

3. Royal Jelly:-A nutritious substance fed to queen bees, used in skincare, supplements, and cosmetics.

4. Bee Pollen:-Rich in protein, vitamins, and minerals, used as a dietary supplement and in cosmetics.

5. Bee Venom:-Used in medical treatments for arthritis, multiple sclerosis, and other conditions.

6. Honeycomb:-Used in food presentation, crafts, and as a natural filter.

7. Beeswax Absolute:-A fragrance used in perfumes, aromatherapy, and cosmetics.

8. Apitoxin:-A component of bee venom, used in medical research and treatments.

9. Melittin:-A peptide found in bee venom, used in medical research and treatments.

10. Bee Brood:-Used as a food source in some cultures and as a nutritional supplement.

These bi-products have various applications in industries like:

1. Cosmetics and skincare
2. Pharmaceuticals and medicine
3. Food and beverages
4. Crafts and art
5. Aromatherapy and perfumery

Volume: 04 Issue No: 12

VARIOUS SCHEMES TO ENHANCE THE ECONOMIC STATUS OF LIVESTOCK FARMERS IN INDIA

Article ID: AG-V04-I12-145

Abhishek Kumar*

Assistant Professor, Veterinary Clinical Complex (VGO), COVAS, Kishanganj, India

*Corresponding Author Email ID: abhiawadhesarita@gmail.com

Abstract

Livestock farming plays a pivotal role in the Indian economy, contributing significantly to the agricultural GDP and serving as a primary livelihood source for millions of rural households. Despite its importance, livestock farmers often face numerous economic challenges, including inadequate infrastructure, limited access to credit, and low productivity. To address these issues, the Indian government and various organizations have implemented a range of schemes aimed at enhancing the economic status of livestock farmers. These schemes focus on improving livestock health, ensuring access to affordable credit, promoting technological interventions, and facilitating market linkages. The key initiatives are National Livestock Mission (NLM), Rashtriya Gokul Mission (RGM), and the Dairy Entrepreneurship Development Scheme (DEDS), among others. This article explores their objectives, implementation mechanisms, and outcomes in empowering farmers and boosting livestock productivity. There is a need for a holistic approach that integrates grassroots-level participation to ensure sustainable economic development for livestock farmers in India. By addressing the existing challenges and leveraging government initiatives, livestock farming can significantly contribute to rural prosperity and food security in the country.

Introduction

India is home to one of the largest livestock populations in the world, with the sector playing a crucial role in the livelihoods of rural communities. Livestock farming not only serves as a source of food and nutrition but also acts as a vital economic activity that supplements agricultural income and provides employment to millions of small and marginal farmers.

According to the National Accounts Statistics, the livestock sector contributes nearly 4.5% to the total GDP and over 25% to the agricultural GDP, highlighting its immense significance in the Indian economy.

However, livestock farmers in India face several persistent challenges that hinder their economic progress. Issues such as inadequate veterinary infrastructure, lack of access to quality feed and fodder, limited availability of financial services, and low adoption of advanced technologies continue to impede productivity and profitability. Additionally, the sector remains vulnerable to climate change, animal diseases, and market volatility, further exacerbating the difficulties faced by farmers.

Recognizing the potential of livestock farming to drive rural development and enhance economic stability, the Indian government has introduced a series of targeted schemes and programs. These initiatives aim to address the core challenges faced by livestock farmers and create an enabling environment for sustainable growth. By focusing on areas such as animal husbandry, dairy development, poultry farming, and skill development, these schemes seek to improve productivity, ensure better income generation, and uplift the economic status of livestock farmers.

This paper provides comprehensive overview of various government schemes and programs designed to support livestock farmers in India. These schemes aim to improve breed quality, enhance milk production, encourage fodder development, ensure animal health, and boost entrepreneurship in the livestock sector. Here are key schemes:

1. Livestock Health and Disease Control (LH &DC)

Objective: Reduce risk to animal health through prophylactic vaccination, capacity building, disease surveillance, and improved veterinary infrastructure.

- **Key Components**:
  - ❖ **Critical Animal Disease Control Programme (CADCP)**:
    - Vaccinate all sheep and goats against Peste des Petits Ruminants (PPR).
    - Vaccinate the entire pig population for Classical Swine Fever (CSF).
    - Target eradication of PPR and CSF by 2030.
  - ❖ **Veterinary Services at Farmers' Doorstep**:
    - Establish and strengthen Mobile Veterinary Units (ESVHD-MVU).
  - ❖ **Assistance to States/UTs for Control of Animal Diseases (ASCAD)**:

- Focus on control of prevalent diseases like PPR, Hemorrhagic Septicemia (HS), Black Quarter (BQ), Enterotoxaemia (ET), Anthrax, and Rabies.
- Funding: 60% from the Central Government and 40% from the State Governments.

LH&DC scheme and National Animal Disease Control Programme (NADCP) for control of FMD and Brucellosis has been merged into a single scheme i.e. Livestock Health and Disease Control Programme (LHDCP).

2. National Animal Disease Control Programme (NADCP) scheme

- Control Foot & Mouth Disease (FMD) and Brucellosis.
- 100% funding for FMD vaccination from the Centre.
- Vaccination of all female calves aged 4-8 months against brucellosis.

3. Animal Husbandry Infrastructure Development Fund (AHIDF)

- **Launched Under**: Atma Nirbhar Bharat Abhiyan stimulus package with ₹15,000 crore.
- **Objective**: Promote dairy and meat processing infrastructure and ensure balanced animal nutrition.
- **Key Focus Areas**:
  - ❖ Establish dairy and meat processing units with value addition.
  - ❖ Enhance protein-enriched quality food availability to combat malnutrition.
  - ❖ Develop quality animal feed plants to provide balanced rations.
- **Outcomes**:
  - ❖ Encourage entrepreneurship and employment generation.
  - ❖ Increase export potential in the dairy and meat sectors.

4. Supporting Dairy Cooperatives and Farmer Producer Organizations (SDCFPO)

- **Objective**: Provide working capital loans to State Cooperatives and Federations to stabilize milk procurement and ensure farmer income.
- **Key Features**:
  - ❖ Soft working capital loans managed by National Dairy Development Board (NDDB).
  - ❖ Support for procurement, storage, and market access of products like Skimmed Milk Powder (SMP), Whole Milk Powder (WMP), White Butter, and Ghee.
- **Impact**:
  - ❖ Enable timely payment to dairy farmers during adverse market conditions.

    - Maintain stable milk procurement prices, especially in the flush season.
- Union Cabinet approved implementation of Supporting Dairy Cooperatives and Farmer Producer Organizations engaged in dairy activities (SDCFPO) as a part of Umbrella Scheme " Infrastructure Development Fund

5. Dairy Processing & Infrastructure Development Fund (DIDF)

- **Objective**: Modernize milk processing plants and create additional infrastructure to enhance milk processing capacity.
- **Implemented By**:
    - National Dairy Development Board (NDDB).
    - National Cooperative Development Corporation (NCDC).
- **Eligible Entities**:
    - Milk Unions, State Dairy Federations, Multi-state Milk Cooperatives, Milk Producer Companies, and NDDB subsidiaries.
- **Key Infrastructure Supported**:
    - Milk processing and chilling plants.
    - Value-added product plants (e.g., butter, cheese, flavored milk).
    - Milk transportation systems (e.g., insulated tankers).
    - Marketing infrastructure (cold chains, deep freezers, parlors).
    - Renewable energy and energy-efficient facilities.
    - Information Technology and ICT systems for milk traceability (e.g., block chain technology).
    - R&D (lab & equipment, new technology, innovations, product development etc)
    - Cattle feed go-downs
    - Packaging material manufacturing units for dairy purposes
    - Training centre

6. National Programme for Dairy Development (NPDD)

- **Objective:** To enhance the quality of milk and milk products, increase the share of organized milk procurement, and strengthen market linkages.
- **Components:**

Component A: Focus on infrastructure development for quality milk production.

- **Activities:**

- ❖ Create and strengthen infrastructure for quality milk testing and chilling.
- ❖ Support for State Cooperative Dairy Federations, District Milk Unions, SHG-run private dairies, Milk Producer Companies, and Farmer Producer Organizations.

Component B: Externally aided project (with Japan International Cooperation Agency (JICA) funding) implemented in Uttar Pradesh and Bihar (2021-2026) as a pilot.

Activities:

- ❖ Build infrastructure for market linkages in villages.
- ❖ Upgrade dairy processing and marketing facilities.
- ❖ Enhance the capacity of producer-owned institutions at village and State levels.

Outcome: Improved returns for milk producers through better market access and upgraded infrastructure.

7. Livestock Census and Integrated Sample Survey (LC & ISS)

- **Objective:** To provide accurate data on livestock population and production to guide policy-making and resource allocation.
- **Key Components:**
  - **Livestock Census (LC):**
    - Conducted every five years since 1919.
    - Latest (20th Census) utilized tablets and the "eLISS" app for Breed-wise livestock data collection.
  - **Integrated Sample Survey (ISS):**
    - ❖ Annual surveys to estimate production of Milk, Eggs, Meat, and Wool at national and state levels.
    - ❖ Results published in the annual Basic Animal Husbandry Statistics report.
- **Advancements:**
  - ❖ Transition from traditional paper-based methods to Computer Assisted Personal Interviewing (CAPI).
  - ❖ Real-time data entry via "eLISS" app for accuracy and efficiency.

Impact and Significance

National Programme for Dairy Development (NPDD):

1. Improves the quality and hygiene of milk and milk products.
2. Encourages organized procurement systems, benefiting smallholder farmers.

3. Enhances rural incomes through better market infrastructure and access.

Livestock Census and Integrated Sample Survey:

1. Provides reliable data to assess livestock resource potential.
2. Supports effective planning for disease control, breed improvement, and market development.
3. Facilitates evidence-based policy formulation and implementation.

8. National Livestock Mission (NLM)

The **National Livestock Mission (NLM)**, launched in 2014 and realigned in 2021-22, aims to promote sustainable growth in the livestock sector, with a focus on employment, entrepreneurship, and per animal productivity. The mission aligns with national objectives to enhance income generation, nutritional security, and rural development. Below are the **key objectives and features**:

Objectives:

1. **Employment Generation and Entrepreneurship Development:**
   - ❖ Focus on small ruminants (goats, sheep), poultry, piggery, and the fodder sector.
   - ❖ Support entrepreneurs through skill development, access to infrastructure, and market linkage.
2. **Increase Per Animal Productivity:**
   - ❖ Promote breed improvement programs to enhance the genetic potential of livestock.
3. **Enhance Production:**
   - ❖ Target increased production of **meat, egg, goat milk, wool**, and fodder to meet growing demand.
4. **feed and fodder Development:**
   - ❖ Strengthen the supply chain for fodder seeds.
   - ❖ Enhance the availability of certified fodder seeds and encourage fodder processing units to address the demand-supply gap.
5. **Risk Management Measures:**
   - ❖ Introduce and expand **livestock insurance** to provide financial protection to farmers.

6. **Promote Research and Technology:**
   - Encourage applied research in prioritized areas, such as poultry, sheep, goat, and fodder.
7. **Capacity Building and Extension Services:**
   - Strengthen extension services to ensure livestock owners receive adequate support and guidance.
   - Offer skill-based training to improve production techniques and reduce costs.

Salient Features of the Realigned NLM:

- Emphasis on **small and marginal farmers** and rural entrepreneurs.
- Increased focus on the **fodder sector**, addressing shortages and ensuring year-round feed availability.
- Expansion of value-added activities such as **fodder processing units** and breed improvement programs.
- Strengthened institutional mechanisms for delivery of services and financial support.

Expected Outcomes:

- Boost to **rural livelihoods** through better income and employment opportunities.
- Improved **livestock productivity**, meeting domestic and export market demands.
- Enhanced **nutritional security** through increased availability of animal products.
- Strengthened resilience of farmers to market and climatic risks through insurance and risk mitigation measures.

9. Rashtriya Gokul Mission (RGM)

Overview

- Launch Year: 2014
- Continuation: Under the umbrella scheme Rashtriya Pashudhan Vikas Yojna (2021-2026).
- Budget: ₹2400 crore.
- Objective: To enhance the productivity of bovines, promote indigenous breeds, and integrate advanced breeding technologies.

Objectives

- Increase bovine productivity and milk production sustainably.
- Propagate the use of high-genetic-merit bulls for breeding.
- Expand Artificial Insemination (AI) services to farmers' doorsteps via MAITRIs.

- Conserve and scientifically promote indigenous breeds by establishing and supporting Gaushalas, Gosadans, Pinjarapoles and Rashtriya Kamdhenu Aayog.
- Implement IVF Technology i.e. to establish IVF laboratories and use *In Vitro* Embryo Production (IVEP) for assured pregnancies.

Funding Pattern

- 100% Grant-in-Aid: For most components.

Subsidy-based Funding for:

- Breed Improvement through IVF: ₹5000 per IVF pregnancy to participating farmers.
- Sex-Sorted Semen Use: Subsidy up to 50% of the cost.
- Breed Multiplication Farms: Subsidy of up to 50% of capital costs, capped at ₹2 crore per project.

Expected Outcomes

- Enhanced milk production and productivity of bovines.
- Conservation of indigenous cattle breeds, boosting their economic value.
- Increased AI coverage to ensure efficient and targeted breeding.
- Creation of a sustainable and digitized bovine management ecosystem (Livestack).
- Empowerment of farmers through skill development and access to advanced technologies.

Significance

The Rashtriya Gokul Mission aims to transform India's cattle economy by leveraging advanced technologies and promoting indigenous breeds. By ensuring access to high-quality germplasm and AI services, it enhances productivity while preserving biodiversity, ultimately contributing to the livelihood of rural communities and the growth of the dairy sector.

10. Dairy Entrepreneurship Development Scheme (DEDS)

The Dairy Entrepreneurship Development Scheme (DEDS) is implemented by the National Bank for Agriculture and Rural Development (NABARD) to promote dairy farming, enhance milk production, and improve the rural economy.

Objectives

1. Promote modern dairy farming and encourage sustainable practices.
2. Provide financial assistance to farmers for setting up and upgrading dairy units.
3. Enhance milk production and increase rural incomes.

4. Strengthen the supply chain by supporting equipment purchase and infrastructure development.

Key Features

- **Loan Limit**: Maximum loan of ₹7.5 lakhs.
- **Subsidy**:
  - 25% for general category beneficiaries.
  - 33.33% for SC/ST beneficiaries.
- **Interest Rates**: Vary between 9% and 12%.
- **Repayment Period**: Loans are generally repayable within 3 to 7 years.

Activities Supported

1. **Establishing modern dairy farms**:
2. **Purchase of dairy equipment**:
   - Milk chillers, separators, and milking machines.
3. **Infrastructure development**:
   - Construction of sheds and waste management systems.
4. **Breed improvement programs**:
   - Purchase of high-yielding milch animals.

Significance

- Encourages entrepreneurship in the dairy sector.
- Helps farmers modernize their operations, leading to higher productivity and quality.
- Provides an opportunity for economically weaker sections, especially SC/ST beneficiaries, to benefit from increased subsidies.
- Supports India's dairy industry in meeting domestic and global demand for milk and milk products.

Conclusion

The economic empowerment of livestock farmers is essential for fostering rural development and ensuring inclusive growth in India. The various schemes implemented by the Indian government have played a significant role in improving livestock productivity, enhancing income generation, and addressing critical challenges faced by farmers. These initiatives have promoted access to credit, advanced technologies, veterinary care, and market opportunities, thereby contributing to the overall economic well-being of livestock farmers. However, the effectiveness of these schemes can be further improved through targeted policy interventions, enhanced awareness campaigns, and the development of robust infrastructure. Greater collaboration between government agencies, financial institutions, and grassroots organizations is crucial to ensure that the benefits of these programs reach all stakeholders, especially small and marginal farmers. Additionally, promoting technological advancements, sustainable livestock management practices, and climate-resilient strategies will help address emerging challenges and ensure long-term growth. By strengthening existing schemes and addressing the gaps in implementation, India can unlock the full potential of its livestock sector, improve rural livelihoods, and contribute significantly to national food security and economic development.

Reference

https://dahd.gov.in/schemes-programmes

Volume: 04 Issue No: 12

AZOLLA: A POTENTIAL BIOFERTILIZER AND LIVESTOCK FEED

Article ID: AG-V04-I12-146

M.Jeya Bharathi, *R.Latha, A.Selvarani and S.Suresh

ICAR – Krishi Vigyan Kendra , Thirupathisaram – 629 901

Kanyakumari District, Tamil Nadu, India

*Corresponding Author Email ID: latharamaiah@yahoo.co.in

Introduction

Azolla is an aquatic floating fern, found in temperate climate suitable for paddy cultivation. The fern appears as a green mat over water. The Blue Green Algae cyanobacteria (*Anabaena azollae*) present as a symbiont with this fern in the lower cavities actually fixes atmospheric nitrogen. The rate of nitrogen fixed is around 25 kg/ha.

As green manure, *Azolla* is grown alone for two to three weeks in flooded fields. Afterwards, water is drained out and *Azolla* fern is incorporated in the field before transplanting of paddy. Otherwise, 4-5 q of fresh *Azolla* is applied in standing water one week after planting of paddy. Dry Azolla flakes can be used as poultry feed and green Azolla is also a good feed for fish. It can be used as a bio-fertilizer, a mosquito repellent, in the preparation of salads and above all as a bio-scavenger as it takes away all heavy metals.

Advantages of Azolla

1. It easily grows in wild and can grow under controlled condition also.
2. It can easily be produced in large quantity required as green manure in both the seasons – Kharif and Rabi.
3. It can fix atmospheric CO_2 and nitrogen to form carbohydrates and ammonia respectively and after decomposition it adds available nitrogen for crop uptake and organic carbon content to the soil.
4. The oxygen released due to oxygenic photosynthesis, helps the respiration of root system of the crops as well as other soil microorganisms.
5. It solubulises Zn, Fe and Mn and make them available to the rice.

6. Azolla suppresses tender weeds such as *Chara* and *Nitella* in a paddy field.
7. Azolla releases plant growth regulators and vitamins which enhance the growth of the rice plant.
8. Azolla can be a substitute for chemical nitrogenous fertilizers to a certain extent (20 kg/ha) and it increases the crop yield and quality.
9. It increases the utilisation efficiency of chemical fertilizers.
10. It reduces evaporation rate from the irrigated rice field.

Nutritional value in Azolla

Azolla is very rich in protein (25-35%), Calcium (67 mg/100g) and Iron (7.3 mg/100g). The comparative analysis of the nutrient content of azolla vis-à-vis other fodder source is depicted in the following table.

Cultivation

The biomass production under natural condition *i.e.* in rice field is only 50 g/ sq.m/day as against optimum production of 400 g/sq.m/day. The production efficiency can be increased by reducing contamination and competition with other algae. This can be achieved by growing Azolla in pits lined with synthetic polythene sheet in courtyard /back yard preferably in open space or on terrace where availability of sunlight is adequate. Although production of azolla is good in nursery plots, production of azolla as green manure in paddy fields; 10% area of the paddy field is cordoned off and azolla is grown. The land should be puddled and leveled so that standing water is uniform throughout the field. Azolla inoculum is sprinkled in the plot and 45 kg of single super phosphate per acre is applied in the field. The land used for cultivation of azolla is not wasted because after broadcasting azolla in the transplanted paddy crop (four days after transplantation) the plot itself may be used for cultivation of paddy. Even the water bodies, ditches in the vicinity can also be used for production of azolla.

Azolla cultivated for fish feed, is grown *in situ* in the pond. A part of the pond is earmarked and is cordoned off by rope made up of straw. Once the mat is formed azolla is released slowly to the pond by lifting the rope. Setting up of Azolla fodder plot does not require expertise and farmers themselves can handle it with ease. If set up in backyard, the area should be leveled and lined with bricks. The side of the plots should be raised to enable the water to stand. Alternatively, the fodder plot can be in a pit with depth of 0.2 m. A polythene sheet is spread over the bed in such a way that 10 cm of standing water can be maintained. Width of the bed is maintained at 1.5 m to enable the cultural operation from both sides. Length may be varied depending upon the fodder requirement of the unit. For two cows, two units of beds of length 2.5 m each with an area of around 8 sq m can meet 50% of the green fodder requirements. Once the bed of size 2.5 m x 1.5 m is ready, about 15 kg of fine sieved soil is spread over the bed, which will provide nutrient to the azolla plant. About 5 kg of pre-decomposed (2 days) cow dung is mixed with the water, which provides carbon source for the azolla.

About 40 g of nutrient mix (made by mixing 10 kg Rock phosphate, 1.5 kg Magnesium salt and 500 g of Murate of potash) is added to the azolla bed. The solution is fortified with micronutrient of desired quantity. This not only takes care of the micronutrient requirement of azolla but also the cattle when it is fed with the azolla. Sufficient water is added to make the water level of the bed to 10 cm.

Azolla cultivation under controlled condition

- Select pit with 2.5 Meter length, 1.5 Meter width and 0.2 Meter depth or cement tank
- Cover the pit or cement tank with plastic sheet or black or blue tharpolin sheet tightly
- Above the tarpaulin sheet apply 10 Kg of soil and that will supply the nutrient for Azolla growth
- 5 kg dried farm yard manure should be mixed with water and pour above the soil. That will supply carbon source. Apply 40g of fertilizer mixture ((Rock phosphate (33g), magnesium sulphate (5g) and murete of potash (2g)). This will supply the nutrient for Azolla growth.
- Pour water on the prepared tank or pit. Always maintain the stagnant water upto 10 cm above the soil portion.

- Apply cow dung slurry once in 7 days and sprinkle the 40gm fertilizer mixture as above
- Care should be taken in such a way that it should not be exposed to direct sunlight
- Cover the prepared pit or tank with coconut leaf or net
- Within 30 days there will be full growth of Azolla
- 50 to 100g of Azolla can be obtained from 1 square centimeter

Conclusion

Since Azolla is having N fixing capacity, fast growing nature, short duration farmers are using Azolla for rice cultivation as a biofertilizers, feed for fish and livestock.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

MATHEMATICAL MODELS SHAPING AGRICULTURAL SYSTEMS

Article ID: AG-VO4-I12-147

Dr. S. Anandhi*

Assistant Professor (Mathematics), Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli-620 027, India

*Corresponding Author Email ID: anandhi.s@tnau.ac.in

Abstract

Mathematical modeling has transformed agriculture by offering quantitative tools for outcome prediction, resource optimization, and informed decision-making. This study explores diverse applications of mathematical models in agriculture, encompassing crop growth prediction, pest control strategies, economic planning, and climate change adaptation measures. By examining the range of modeling techniques and their practical implementations, this report seeks to demonstrate how these models contribute to sustainable farming practices and enhance the resilience of food production systems.

Introduction

Mathematical modeling in agriculture is a powerful tool for understanding and optimizing complex agricultural systems. It involves the use of mathematical equations and simulations to represent biological, physical, and economic processes, thereby enabling precise analysis and prediction. By integrating data on climate, soil properties, crop growth, pest dynamics, and market trends, these models can assist in planning and decision-making at various scales, from individual farms to regional and global food systems. The importance of mathematical modeling has grown significantly owing to rising challenges, such as climate change, resource limitations, and the need for sustainable agricultural practices. Models help streamline the efficient use of inputs, such as water and fertilizers, reducing costs and environmental impact. They also contribute to the timely prediction of pest outbreaks and disease spread, thereby minimizing potential crop losses. Economic models support farm profitability by guiding resource allocation and production strategies. Through advancements in data collection technologies, such as remote sensing and IoT, mathematical modeling now plays a central role in precision agriculture, ensuring that interventions are applied where they are needed most. This approach not only maximizes productivity but also safeguards long-term soil health and ecosystem balance.

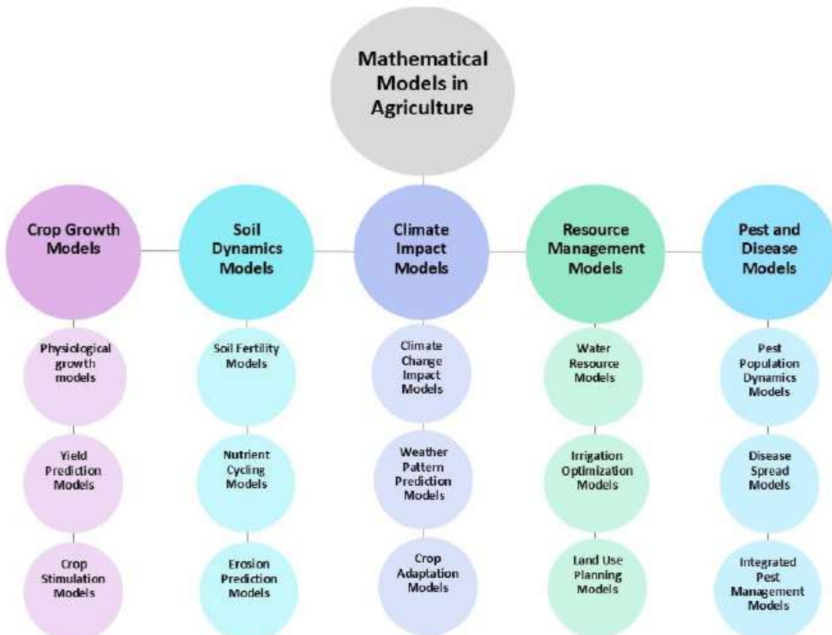
1. Types of Mathematical Modeling in Agriculture

Mathematical models in agriculture can be classified into various types, each serving different purposes and applications. The main categories include deterministic, stochastic, static, dynamic, mechanistic, empirical, optimization, simulation, hybrid, spatial, agent-based, and system dynamics models. Each type has unique strengths and is chosen based on the specific agricultural problem, data availability, and required detail.

- Deterministic Models: Produce consistent outputs for a given set of conditions, ideal for predictable scenarios such as crop growth.
- Stochastic Models: Incorporate randomness to account for variability, useful in pest and disease spread modeling.
- Static Models: Offer snapshots of systems at a point in time for decision-making.
- Dynamic Models: Simulate changes over time, essential for long-term planning and crop growth analysis.
- Mechanistic Models: Detail processes based on biological and physical mechanisms, providing insight into soil and plant interactions.
- Empirical Models: Data-driven, derived from observations, often used for yield prediction.
- Optimization Models: Aid in maximizing resource use efficiency through linear or nonlinear programming.
- Simulation Models: Test strategies under various conditions, reducing real-world risks.
- Hybrid Models: Combine empirical and mechanistic aspects for enhanced accuracy.
- Spatial Models: Integrate geographic data for regional analysis and pest spread tracking.
- Agent-Based Models: Model individual interactions within an ecosystem.
- System Dynamics Models: Capture feedback loops for complex, interconnected systems over time.

2. Applications of Mathematical Models in Key Areas of Agriculture

Mathematical models in agricultural systems represent s analytical frameworks that bridge scientific understanding with practical agricultural management. By transforming complex biological, environmental, and economic interactions into quantifiable systems, these models provide critical insights across crop growth, soil dynamics, climate impacts, resource management, and pest control. Modern agricultural researchers utilize these models to simulate crop physiological processes, predict yield outcomes, analyze soil fertility, anticipate climate change effects, optimize water resources, and develop integrated pest management strategies. The application of mathematical models in agricultural systems are broadly classified as given below.



3.1 Crop Growth and Yield Prediction

Mathematical models simulate biological and environmental interactions to predict crop development. Phenological models use temperature and growing degree days (GDD) to forecast growth phases, while process-based models like Crop Environment Resource Synthesis (CERES) and Agricultural Production Systems Simulator (APSIM) simulate the entire crop cycle, from germination to harvest.

The Phenological Model equation for GDD is given by $GDD = \Sigma(T_{max} + T_{min})/2 - T_{base}$

GDD is a measure of heat accumulation used to predict plant development stages. It calculates the sum of daily average temperatures above a base temperature (T_{base}). By tracking GDD, farmers can estimate planting and harvesting times, optimize irrigation schedules, and predict potential yields.

The process-Based Models CERES and APSIM are complex models with numerous equations and parameters. CERES is a suite of crop simulation models that simulates crop growth and development based on environmental conditions like photosynthesis, respiration, water balance and management practices. APSIM is a modular modeling framework that allows for the simulation of various agricultural systems. It incorporates a wide range of models for different components, including crops, soils, and climate that include Logistic growth model, Phenological development models, Richards' equation for Soil Water Balance, Nutrient uptake and mineralization models.

Both CERES and APSIM are highly complex models that require detailed calibration and validation to accurately simulate crop growth and yield.

3.2 Pest and Disease Management

The SEIR (Susceptible, Exposed, Infectious, Recovered) model is a fundamental epidemiological compartmental model used to understand the spread of infectious diseases. The SEIR framework adapted for crops help forecast pest outbreaks and disease spread. The standard SEIR model is described by four coupled differential equations representing the rates of change for each compartment:

$$\frac{dX}{dt} = -\frac{bXZ}{N}$$

$$\frac{dY}{dt} = \frac{bXZ}{N} - c\,Y$$

$$\frac{dZ}{dt} = cY - gZ$$

$$\frac{dR}{dt} = gZ\ ,$$

where X represents the number of Susceptible individuals, Y represents the number of Exposed individuals, Z is the number of Infectious individuals, R represents the number of Recovered individuals, N is the total population (N = X + Y+Z+ R), b is the transmission rate, c is the rate of progression from Exposed to Infectious and g is the recovery rate. The key parameters are $b_r = \frac{b}{g}$, the basic reproduction number, $a_c = \frac{1}{c}$, the average incubation period and $a_g = \frac{1}{g}$, the average infectious period. The SEIR model has significant applications in understanding and managing plant diseases, pest populations, and pathogen spread in crops and livestock by modifying the compartments to represent agricultural-specific scenarios.

3.3 Water Resource Management

Water scarcity poses significant risks, making models like SWAT (Soil and Water Assessment Tool) essential for hydrological assessments. These models guide irrigation planning and efficient water allocation, while maintaining crop yields.

The simple SWAT water balance equation is given by $W_s = W_{s-1} + P - S - G - E - D + L,$

Where W_s , the water storage at time t, W_{s-1}, the previous water storage, $P,$ the precipitation, $S,$ surface runoff, G is groundwater flow, E , the evapotranspiration, D , the deep percolation and L is lateral flow. This simplified equation captures the key components of water movement within a watershed, representing how water storage changes based on inputs (precipitation), outputs (runoff, evapotranspiration, percolation), and lateral water transfers. Each term represents a critical component of the hydrological cycle, allowing researchers and water resource managers to track water movement and balance within a specific watershed or hydrological response unit.

3.4 Soil and Nutrient Management

Nutrient flow models simulate nitrogen and phosphorus movement, informing fertilizer application to minimize leaching. The RUSLE (Revised Universal Soil Loss Equation) model is given by SE = R**K**LS*CP which estimates soil erosion by considering factors like rainfall erosivity (R), soil erodibility (K), slope length and steepness (LS), and crop management (CP) . It helps in identifying areas prone to erosion, selecting appropriate conservation practices, and designing sustainable land management strategies.

3.5 Climate Change Impact Assessment

The integration of mathematical modeling in climate change impact assessment represents a critical advancement in agricultural adaptation planning. Global Climate Models (GCMs) coupled with crop simulation models provide comprehensive insights into the potential impacts of climate change on agricultural productivity. These integrated modeling approaches synthesize complex interactions between atmospheric conditions, soil properties, and crop physiological responses through sophisticated mathematical frameworks. The fundamental relationship governing these models can be expressed as: $Y(t) = f(C(t), S(t), M(t))$

where Y represents crop yield at time t, C denotes climate variables, S represents soil conditions, and M indicates management practices.

Through the application of coupled GCM-crop models, researchers can evaluate the potential of drought-resistant crop varieties in mitigating climate change impacts. The models will demonstrate that adapted varieties could reduce yield losses under projected climate scenarios, providing crucial guidance for agricultural adaptation strategies and regional food security planning.

3.6 Economic Modeling in Agricultural Systems

Economic modeling serves as a fundamental tool for optimizing agricultural operations and decision-making processes through quantitative frameworks. These models integrate various factors including resource allocation, supply chain optimization, and market dynamics. The mathematical foundation typically takes the form of optimization problems, expressed as:

Maximize: $= \sum(PiYi - CiXi)$, Subject to : $AX \leq B$

where Z represents profit to be maximized, Pi denotes product prices, Yi represents yields, and Ci indicates input costs. A significant implementation of the above economic modeling in the production industry can demonstrates its practical value. Through sophisticated modeling of production variables and market conditions, producers can achieve an increase in profitability.

3.7 Precision Agriculture Implementation

The evolution of precision agriculture represents the convergence of mathematical modeling and modern technology, enabling real-time optimization of farming practices. These systems utilize complex spatial-temporal models, represented by:

$$S(x,y,t) = \sum wi * fi(x,y,t) + \varepsilon$$

where S represents soil parameters at location (x,y) and time t, wi denotes weight factors, fi represents sensor measurements, and ε indicates the error term.

3.8 Sustainable Agricultural Practices

Mathematical modeling of sustainable agricultural practices encompasses comprehensive systems analysis of crop rotations, soil health, and environmental impacts. The dynamics of these systems are often represented through differential equations:

$$dN/dt = I(t) - L(t) + M(t)$$

where N represents soil nitrogen content, I(t) denotes input rate, L(t) represents loss rate, and

M(t) indicates mineralization rate. The model captures complex interactions between crops, soil nutrients, and environmental factors, leading to improved soil nitrogen content and enhanced long-term productivity.

3.9 Livestock Management Systems

The application of mathematical modeling in livestock management encompasses nutrition optimization, disease control, and production efficiency. Growth models are expressed as:

$$G(t) = \alpha * F(t) - \beta * M(t)$$

where G represents growth rate, F denotes feed intake, M represents maintenance requirements, and α, β are efficiency parameters. A comprehensive study of this model can exemplify its practical benefits in livestock management.

3.10 Genetic and Breeding Programs

Mathematical modeling has revolutionized genetic improvement programs through sophisticated algorithms and statistical approaches. Breeding value estimation is represented as:

$$BV = \sum(Mi * \alpha i) + \varepsilon$$

where BV represents breeding value, Mi denotes marker effects, αi represents allele status, and ε indicates environmental factors. Many Research in rice breeding programs highlights the impact of mathematical modeling in genetic improvement. This modeling technique can be utilised to develop drought-tolerant rice varieties, significantly shortening breeding cycles while improving trait selection efficiency.

Conclusion

The integration of mathematical modeling across these diverse areas of agriculture has fundamentally transformed the sector's approach to decision-making and optimization. From climate change adaptation to genetic improvement, mathematical models provide the quantitative framework necessary for advancing agricultural efficiency and sustainability. As technology continues to evolve and data availability increases, the role of mathematical modeling in agriculture will become increasingly central to addressing global food security challenges and promoting sustainable agricultural development.

References

Jones, A., & Smith, B. (2023). "Advances in Crop Simulation Modeling: A Comprehensive Review." *Agricultural Systems*, 215, 103-125.

Kumar, R., et al. (2024). "Precision Agriculture: Integrating Remote Sensing and Mathematical Modeling for Sustainable Farming." *Remote Sensing of Environment*, 287, 113-129.

Williams, T.G., & Rodriguez, M. (2022). "Climate Change Impact Assessment in Agricultural Systems: A Global Perspective." *Climatic Change*, 172(3-4), 45-67.

Chen, L., et al. (2023). "Agent-Based Modeling in Agricultural Ecosystems: Techniques and Applications." *Ecological Modelling*, 480, 110-128.

Patel, S.K., & Nguyen, H. (2024). "Water Resource Management through Advanced Hydrological Modeling." *Water Resources Research*, 60(2), 215-235.

Müller, C., & Schmidt, H. (2022). "Economic Optimization Models in Agricultural Production Systems." *Agricultural Economics*, 53(4), 567-589.

Okafor, G., et al. (2023). "Stochastic Modeling of Pest Dynamics in Crop Production." *Journal of Agricultural and Applied Economics*, 55(3), 401-420.

Zhang, W., & Liu, Y. (2024). "Machine Learning Approaches to Crop Yield Prediction." *Nature Machine Intelligence*, 6(1), 45-59.

Santos, R.M., et al. (2022). "Soil Nutrient Dynamics: Advanced Modeling Techniques." *Geoderma*, 412, 115-133.

Thompson, J.R., & Gupta, A. (2023). "System Dynamics in Agricultural Sustainability Assessment." *Sustainability Science*, 18(2), 267-285.

Nakamura, K., et al. (2024). "Genetic Breeding Optimization through Advanced Mathematical Modeling." *Theoretical and Applied Genetics*, 137(4), 789-810.

Rodriguez-Gonzalez, P. (2022). "Precision Agriculture Technologies: A Comprehensive Modeling Framework." *Agricultural Systems*, 200, 103-122.

Ahmed, M., & Singh, R. (2023). "Climate Change Adaptation Strategies in Agriculture: Modeling Approaches." *Global Change Biology*, 29(7), 1456-1475.

Volume: 04 Issue No: 12

HARNESSING BIOLOGICAL CONTROL METHODS TO MANAGE RUGOSE SPIRALING WHITEFLY INFESTATIONS ON OIL PALM AND COCONUT PLANTATIONS

Article ID: AG-VO4-I12-148

***Dr. Vadde Mounika [1] and Dr. G. Vijaya krishna [2]**

[1] Department of Vegetable science, HRS, Aswaraopet, SKLTHU, Telangana-507301, India

[2] Scientist, Department of Horticulture, HRS, Aswaraopet, SKLTSHU, Telangana-507301, India

*Corresponding Author Email ID: vaddemounika.vjmy15@gmail.com

Introduction

Oil palm (*Elaeis guineensis*) and coconut (*Cocos nucifera*) are two of the most important plantation crops cultivated across the tropical regions of the world, playing a pivotal role in the socio-economic fabric of millions of people. Both crops are valued for their versatility, as they provide a wide array of products, including edible oils, beverages, fiber, biofuels, and industrial raw materials. Oil palm is predominantly grown for its fruit, which yields palm oil and palm kernel oil. These oils constitute approximately 30% of the global vegetable oil market, making oil palm the world's leading oil crop. India, despite being one of the largest consumers of palm oil, heavily depends on imports, importing over 9 million tonnes annually, with a substantial portion sourced from Southeast Asia. The area under oil palm cultivation in India is approximately 3.6 lakh hectares, with the government aiming to expand it to 10 lakh hectares by 2025 under the National Mission on Edible Oils–Oil Palm (NMEO-OP). Coconut is often referred to as the "Tree of Life" due to its ability to provide food, drink, shelter, and fuel. Key products include copra, coconut oil, tender water, and coir. India ranks among the top global producers of coconuts, contributing over 33% of the world's coconut production, with Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh being the major coconut-growing states. India has an estimated 2.3 million hectares under coconut cultivation, with an annual production of 21.7 billion nuts. Together, these crops contribute significantly to the livelihoods of farmers and the agro-industrial sector, with annual economic contributions worth billions of rupees.

Emerging Challenges – Rugose Spiralling Whitefly

Despite their economic importance, the production and productivity of oil palm and coconut are severely constrained by pest infestations. Among the major pests, whiteflies are a major pest affecting coconut and oil palm cultivation, significantly impacting the productivity and health of these economically important crops. The Rugose Spiralling Whitefly (*Aleurodicus rugioperculatus*), an invasive exotic pest first reported in India in 2016, has emerged as a significant threat. Its rapid spread, facilitated by favorable tropical conditions and a lack of natural enemies, has caused 30–40% yield losses in infested areas, particularly along India's coastal regions. Managing this pest has become a priority to safeguard the sustainability of these vital crops.

Exotic Whitefly Species Invading India

1. **Rugose Spiralling Whitefly (*Aleurodicus rugioperculatus*)** (2016):
   - This species was the first to be detected among the invasive whiteflies in India.
   - It produces a significant amount of honeydew, which supports the growth of sooty mold, affecting photosynthesis and reducing the vigor of host plants.
   - Commonly found in coastal and backwater regions, where environmental conditions are conducive to its proliferation.
2. **Bondar's Nesting Whitefly (*Paraleyrodes bondari*)** (2018):
   - Detected in oil palm plantations, this whitefly nests in colonies and lays eggs covered with waxy secretions.
   - It causes direct damage by sucking sap and indirect damage through the spread of secondary fungal infections.
3. **Nesting Whitefly (*Paraleyrodes minei*)** (2018):
   - Similar to Bondar's nesting whitefly, this species has a waxy protective cover.
   - It affects coconut palms, leading to defoliation and reduced nut yield.
4. **Palm-Infesting Whitefly (*Aleurotrachelus atratus*)**:
   - This species predominantly targets oil palms and coconuts.
   - Its infestation leads to chlorosis, stunted growth, and even plant mortality in severe cases.

Host range

The rugose spiraling whitefly (*Aleurodicus rugioperculatus*) has a broad host range, including field crops, plantation crops, horticultural crops, ornamental, and landscape plants. However, it shows a strong preference for palms, particularly coconut, oil palm, and ornamental palms. It thrives better on non-native plants, enabling it to adapt to abiotic stresses and compensate for resource limitations. This adaptability accelerates its population growth and facilitates geographic expansion. The pest's rapid host range expansion poses significant challenges for crop management and biodiversity conservation.

Symptoms

Concentric waxy Spirals:

- Found on the undersurface of leaves and other plant parts, such as leaf petioles and tender nuts, due to egg-laying activity.

White Mealy waxy Material:

- Nymphs and adults produce a thick flocculent waxy coating, creating a nuisance in heavily infested areas.

Aggressive Sap Sucking:

- Both nymphs and adults extract large quantities of sap, leading to nutrient and water depletion. This causes reduced plant vigor and stress.

Honeydew Secretion and Sooty Mold Formation:

- Excessive honeydew secretion supports the growth of black sooty mold, darkening the upper leaf surfaces and understory crops.

Photosynthesis and Aesthetic Value:

- The whitefly secretes honeydew, which supports the growth of sooty mold fungus on the leaf surface. The black sooty mold blocks sunlight, interfering with photosynthesis. This reduces the energy available for oil biosynthesis and the development of high-quality fresh fruit bunches (FFBs).
- Severe infestation damages the plant's appearance, leading to the premature drying and dropping of fronds.

Nutrient Depletion:

- Nymphs and adults of the whitefly feed by sucking plant sap, which depletes the plant's reserves of water and essential nutrients.
- This results in weaker fronds, lower chlorophyll content, and reduced nutrient allocation to fruit bunches, affecting oil content and quality

Yield Loss in Fresh Fruit Bunches (FFBs):

- Research indicates that severe infestation leads to 20–45% yield loss in FFBs due to physiological stress and nutrient diversion for recovery rather than fruit production
- Reduced fruit size and oil-rich mesocarp development lower the quality of crude palm oil (CPO) extracted.

Impact on Fruit Bunches:

- The pest indirectly affects fruit bunch weight and oil-to-bunch ratio. Infested palms often produce smaller and less oil-rich fruits, lowering the overall oil yield

Integrated Management Strategies for Rugose Whitefly

1. **Monitoring and Prevention**:

- Conduct regular monitoring of pest and natural enemy populations across various host plants.
- Avoid transporting infested coconut seedlings or ornamental plants from pest-affected areas to prevent spread.
- To prevent whitefly infestation, the collection of plants from areas already affected by such pests should be stopped. Plants should not be taken until the disease is reduced.

2. **Physical Control**:

- Install yellow sticky traps at 15 traps/ha to monitor and trap adult whiteflies.
- Use water sprays with a sticker to wash off pests from leaves, provided water is abundantly available.
- To control whiteflies, applying castor oil to tarpaulins of about 1.5 to 2 feet in height and placing them around the trunks of coconut and oil palm trees is a cost-effective and efficient agricultural practice. These tarpaulins should be cleaned every alternate day, and the trapped whiteflies should be removed before reapplying castor oil.

3. **Cultural Practices**:

- Avoid excess irrigation and nitrogen fertilizers; adhere to the recommended dosages to maintain palm health and reduce pest attraction.
- The best method to control whiteflies is to grow marigold flowers either around the garden or between the crops. The limonene present in marigold flowers repels whiteflies but does not kill them. This ensures there is no adverse effect on beneficial insects in the crop.

- Rainy days and Irrigation forcefully with pipes on leaves kills the eggs and can reduce the sooty appearance damage due too white fly
- Spraying with rin/surf water/ shampoo can remove the waxy material and eggs on the leaves which helps to control the pest effectively

4. **Biological Control**:

- Periodically release the predator *Apertochrysa (=Psudomallada) astur* at 1000 eggs/ha every 15 days.
- During the monsoon and winter seasons, natural enemies such as parasitoids, predatory insects, and nematodes play an effective role in controlling whitefly pests. However, their impact is reduced during the hot summer months when temperatures are high.
- The parasitoid *Encarsia guadeloupe* collected from whiteflies is effective in controlling the spiral whitefly pest.
- The locally available neuropteran predator *Dicyphus stressa* has been observed to effectively control the disease by feeding on whitefly eggs in their egg stage (HRS Ambajipet)
- Apply *Isaria fumosorosea* (entomopathogenic fungus) at 5 g/L of water (2×10^8 cfu/g) as a foliar spray twice, with a 15-day interval between applications ICAR-NBAIR, Bengaluru.

5. **Chemical Measures**:

- Under severe infestation and lack of natural parasitism, apply neem oil (0.02%) as an eco-friendly alternative.

6. **Enhancing Natural Parasitism**:

- Avoid unwarranted chemical sprays to protect natural enemies like *E. guadeloupae*.
- Conserve and encourage natural parasitoid buildup by planting reservoir plants like banana and *Canna indica*, which offer shelter from pesticides and unfavorable conditions.

7. **Eco friendly insecticide (*Neem-based product*)**

Azadirachtin 10000 ppm (*Neem-based product*)@1.75 ml/L as a foliar spray along with shampoo/ rin soap is more effective in oil palm can control Rugose whitefly upto 97%. Azadirachtin foliar spray was effective at 6th and 8th DAT with 94 per cent mortality in coconut..eco-friendly and moderately effective in reducing whitefly populations Application of insecticides kill the pollinators and beneficiary insects which are useful for pollination.

Decreased oil extraction rates (OER) due to Broad spectrum insecticides

The primary pollinator of oil palm is the weevil *Elaeidobius kamerunicus*, which plays a crucial role in transferring pollen between male and female inflorescences for successful fruit set. Spraying broad-spectrum insecticides to control pests like the rugose spiraling whitefly often kills these weevils, disrupting pollination. This leads to poor fruit set and increased parthenocarpy (development of seedless fruits), which have lower oil content. Consequently, oil extraction rates (OER) decline due to reduced viable fruit yield. To mitigate this, selective use of insecticides and integrated pest management (IPM) approaches, including biopesticides and natural predators, are essential to protect both pollinators and yield

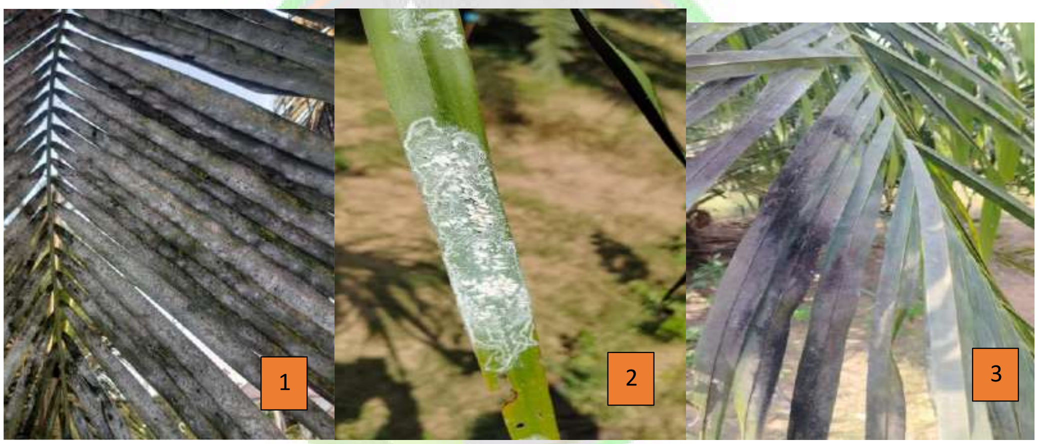


Fig 1&2: White mealy waxy flocculent material on affected palm due to rugose spiralling whitefly

Fig 3: Black sooty mould formation on affected palm due to rugose spiralling whitefly

To control whiteflies on oil palm and coconut, neem oil combined with soap is an effective natural remedy. The neem oil concentration should be 5-10 ml of neem oil per 1 liter of water, with 1 teaspoon of soap (such as Rin or mild shampoo) added as a surfactant. This combination helps the neem oil spread more evenly on plant surfaces, particularly on the undersides of leaves where whiteflies are most active. The neem oil contains azadirachtin, which disrupts the whitefly's life cycle by preventing molting and reproduction. This solution should be sprayed on both the upper and lower surfaces of leaves, ideally in the early morning or late evening. Reapply every 10-14 days for effective control.

To completely eradicate spiral whiteflies, it is essential to maintain cleanliness in orchards and areas where beneficial fungi develop extensively. To prevent the damage caused by these whiteflies and the diseases they spread, awareness programs such as meetings and campaigns should be conducted widely in affected areas to educate farmers on management practices. Field demonstrations should also be organized in orchards severely affected by whiteflies to raise awareness among farmers about controlling the diseases and pests caused by whitefly infestations. Farmers from nearby areas can attend these demonstrations to learn about the management practices for whitefly control.

References

Wankhede, S., Shinde, V., Ghavale, S., & Malshe, K. (2023). Eco-friendly management of rugose spiralling whitefly, Aleurodicus rugioperculatus Martin on coconut under coastal ecosystem of Maharashtra. *Pest Management in Horticultural Ecosystems*, *29*(1).

Selvaraj K, Sumalatha BV, Ramanujam B, Poornesha B, Kandan A, Amala U. Isaria fumosorosea: a Potential Biocontrol agent for management of invasive rugose spiralling whitefly in Coconut and Oilpalm. ICAR: NBAIR publication; c2020. p. 11.

Volume: 04 Issue No: 12

ALLELOCHEMICAL PROPERTIES OF CASTOR: A NATURAL SOLUTION FOR WEED MANAGEMENT AND SOIL HEALTH

Article ID: AG-VO4-I12-149

Rithiga.R[1], Natarajan S.K.[2], Gowsalya. R.[3], ***Elankavi. S[4], Jaya Prabhavathi .S[5]***

[1]PG Scholar, Department Of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirapalli, Tamil Nadu, India- 620 027.

[2*]Associate Professor, Department of Agronomy, Tapioca and Castor Research Station, Yethapur, Tamil Nadu, India- 636 119.

[3] PG Scholar, Department of Agronomy, Agricultural College and Research Institute, Madurai, Tamil Nadu, India- 625 104.

[4]Associate Professor, Department of Agronomy, Tapioca and Castor Research Station, Yethapur, Tamil Nadu, India- 636 119.

[5]Associate Professor, Department of Agricultural Entomology, Tapioca and Castor Research Station, Yethapur, Tamil Nadu, India- 636 119.

*****Corresponding Author Email ID**:** natarajan.s.k@ tnau.ac.in

Abstracts

Castor (*Ricinus communis*), a plant known primarily for its oil-rich seeds, has recently attracted attention in agriculture due to its unique allelopathic properties. Allelopathy is a biological phenomenon where plants release natural chemicals, known as allelochemicals, to influence the growth and survival of neighboring plants. In castor, allelochemicals like ricinine, flavonoids and phenolics are released into the soil through roots, leaves, and seed coatings, effectively inhibiting the germination and growth of weed species. These natural herbicidal effects reduce competition for resources such as sunlight, water, and nutrients, providing a promising eco-friendly solution for weed management.By reducing the dependence on synthetic herbicides, castor allelopathy helps prevent harmful chemical runoff, promotes soil biodiversity, and supports sustainable farming practices. Integrating castor in crop rotations or inter cropping systems can enhance soil health, increase crop yield, and boost farm biodiversity, creating a more balanced and resilient

agro ecosystem. However, implementing castor allelopathy requires careful management, as some sensitive crops may also be affected. Recent field trials in semi-arid regions, such as in parts of India, highlight the practical benefits of using castor in rotation with crops like wheat, significantly reducing weed pressure and enhancing soil organic matter. This study underscores castor's potential in advancing environmentally friendly, cost-effective agricultural practices.

Introduction

As the demand for sustainable and eco-friendly agricultural practices grows, farmers and researchers alike are turning to natural plant properties to help solve persistent challenges in crop management. One such challenge is effective weed management, a critical issue that often leads to significant crop yield losses and increases the cost of production. Traditional methods of weed control, which rely heavily on synthetic herbicides, can have damaging effects on the environment, including soil and water contamination, harm to non-target organisms, and the development of herbicide-resistant weeds. Additionally, the overuse of these chemicals can degrade soil health over time, reducing its capacity to support healthy crops.

Castor (*Ricinus communis*), a plant traditionally cultivated for its oil-rich seeds, has recently gained attention for its natural ability to inhibit weed growth through allelopathy. **Allelopathy** is a process in which a plant releases biochemicals, known as **allelochemicals**, into its surroundings, affecting the growth, survival, and reproduction of neighboring plants. By producing and releasing these compounds, castor can naturally suppress weeds and improve soil health, offering a more sustainable, low-impact alternative to chemical herbicides.

What is Allelopathy and Why is it Important?

Allelopathy is a biological phenomenon where plants release chemicals, called allelochemicals, which affect the growth and development of surrounding plants. These substances are released through various pathways, including roots, leaves, and seed coatings. Allelopathic plants like castor can suppress the growth of neighboring weeds, making them valuable in agricultural systems that aim to reduce chemical herbicide use and improve soil biodiversity.

Allelochemicals in Castor

Castor is particularly notable for its production of ricinine, a potent allelochemical that has shown strong herbicidal effects against weeds. Ricinine and related compounds, such as flavonoids, phenolics and tannin are naturally released into the soil and can inhibit the germination and growth of weed species (Chandrasena *et al.*, 2018). By deploying these chemicals strategically, castor helps reduce competition for resources like sunlight, water, and nutrients, allowing crops to thrive with less interference from unwanted weeds.

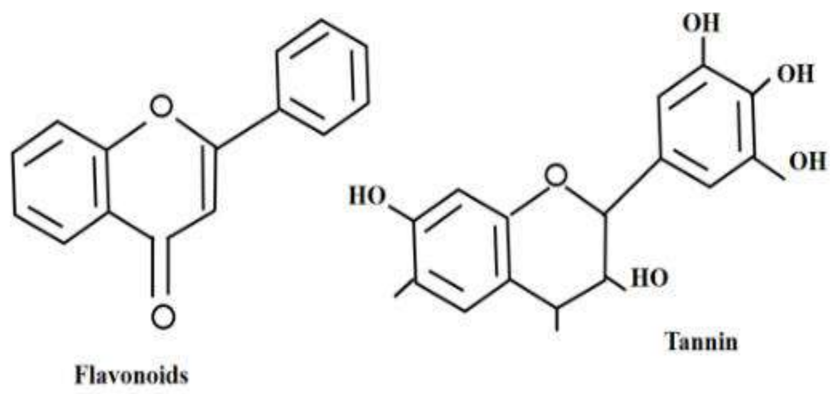


Fig.1. Structure of allelochemicals.

Benefits of Castor Allelopathy in Weed Management and Soil Health

1. **Reducing Dependence on Synthetic Herbicides:** Castor's natural weed-suppressing abilities allow farmers to reduce or even eliminate the use of synthetic herbicides, which can be costly and environmentally harmful. Castor allelopathy provides an organic alternative, helping to prevent chemical runoff that harms waterways and surrounding ecosystems.
2. **Promoting Long-Term Soil Health:** Unlike synthetic chemicals, which can disrupt beneficial soil organisms and degrade soil structure, castor allelochemicals are less harmful to soil biodiversity. Healthier soils foster greater nutrient availability, improved water retention, and stronger plant roots, which together contribute to higher crop yields over time.
3. **Cost-Effective and Eco-Friendly:** For farmers, especially those operating on limited budgets, reducing herbicide use saves money. Castor's natural allelopathy offers an economical way to control weeds without compromising environmental health. This approach supports farmers looking to move toward more sustainable and eco-friendly production methods.
4. **A Biodiversity Boost for Agro ecosystems:** By integrating castor into crop rotations or inter cropping systems, farmers can not only manage weeds but also boost the biodiversity of their farms. This contributes to a more balanced ecosystem, where beneficial organisms such as earthworms, soil microbes, and pollinators can thrive, creating a more resilient farming system overall.

Implementing Castor in Crop Rotations and Inter cropping Systems

Integrating castor into existing farming practices, such as crop rotation or inter cropping, can optimize its allelopathic potential. For example, including castor in rotation with cereal crops or legumes can suppress weed growth while improving soil health for the following crop cycle. Castor's deep root system also aerates the soil, breaking up compact layers and enhancing water infiltration (Kassam *et al.*, 2009). When used as an inter crop, castor can effectively reduce weed pressure in the primary crop, particularly in crops like maize, millet, and certain legumes.

Potential Challenges in Utilizing Castor Allelopathy

Despite its advantages, castor's allelopathic properties must be managed carefully. For instance, some sensitive crops might also be affected by the allelopathic compounds in castor, which means careful planning is essential to avoid crop growth inhibition. Additionally, there is a need to manage castor residues responsibly, as an excessive build up of allelochemicals could have long-term effects on soil fertility and crop productivity.

Conclusion

As agriculture evolves to meet the demands of a growing population and changing climate, solutions like castor allelopathy offer a promising path forward. By harnessing castor's natural weed-suppressing properties, farmers can reduce chemical inputs, enhance soil health and move toward a more sustainable, bio diverse and resilient agricultural model. As research continues to explore the full potential of castor's allelochemicals, it is likely that this versatile crop will play a growing role in the development of greener and more productive farming practices worldwide.

Future Directions and Research

To fully realize castor's potential in agriculture, further research is needed to understand how its allelopathic effects interact with different crop species, soil types, and climates. Advances in understanding castor's allelochemicals could lead to more precise recommendations for integrating castor into diverse farming systems, helping farmers worldwide harness this crop's full range of ecological benefits. By incorporating castor's allelopathic properties into modern farming, we can cultivate not just crops but a healthier, more balanced agricultural ecosystem—one that aligns productivity with environmental stewardship.

Reference

Chandrasena, N., & Narayana, A. (2018). Parthenium Weed: Uses and. *Parthenium Weed: Biology, Ecology and Management*, *7*(190), 3.

Kassam, A., Friedrich, T., Shaxson, F., & Pretty, J. (2009). The spread of conservation agriculture: justification, sustainability and uptake. *International journal of agricultural sustainability*, *7*(4), 292-320.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

ARTIFICIAL INTELLIGENCE: FUTURE OF INDIAN AGRICULTURE AND THEIR APPLICATIONS

Article ID: AG-VO4-I12-150

***R.Vinoth[1], J.Goukula Krishnan[2], J.Sriman Narayanan[3], K.Elayaraja[4] and S.D. Sivakumar[5]**

[1]Teaching Assistant (PBG), Institute of Agriculture, TNAU, Kumulur, Trichy, Tamil Nadu

[2]Assocaite Professor (PBG), IOA, TNAU, Kumulur, Trichy, Tamil Nadu, India

[3]Assocaite Professor (AGM), IOA, TNAU, Kumulur, Trichy, Tamil Nadu, India

[4]Senior Scientist, ICAR- Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, India

[5]Principal, Institute of Agriculture, TNAU, Kumulur, Trichy, Tamil Nadu, India

*Corresponding Author Email ID: rvinothagri@gmail.com

Introduction

The growing world's population and the demand for food rising, it is crucial to use efficient farming methods to increase production on the limited amount of land. AI is becoming more prevalent every day in agriculture, and AI-based devices are elevating the current farming system. Agriculture is dependent on a number of variables, including soil nutrient content, moisture, crop rotation, rainfall, temperature, etc. Products based on artificial intelligence can use these variables to track crop productivity. In order to improve a wide range of agriculture-related tasks throughout the entire food supply chain, industries are turning to Artificial Intelligence technologies.

Despite producing enough food to feed the world's population, nearly one billion people still suffer from hunger and malnutrition because of food wastage, climate change, and other factors. Moreover, with the global population projected to reach 9.7 billion by 2050, the pressure is mounting on the agricultural industry to produce more food while using fewer resources and reducing its environmental impact. Fortunately, the integration of artificial intelligence (AI) in agriculture has the potential to transform food systems and help address the global food crisis. By analyzing data from various sources, AI can help farmers make data-driven decisions, optimize resource usage, and reduce environmental impact. For example, the World Economic Forum has reported that AI integration in agriculture could bring about a 60% decrease in pesticide usage and a 50% reduction in water usage.

Until recently, using the words AI and agriculture in the same sentence may have seemed like a strange combination. After all, agriculture has been the backbone of human civilization for millennia, providing sustenance as well as contributing to economic development, while even the most primitive AI only emerged several decades ago. Nevertheless, innovative ideas are being introduced in every industry, and agriculture is no exception. In recent years, the world has witnessed rapid advancements in agricultural technology, revolutionizing farming practices. These innovations are becoming increasingly essential as global challenges such as climate change, population growth together with resource scarcity threaten the sustainability of our food system. Introducing AI solves many challenges and helps to diminish many disadvantages of traditional farming.

Applications of artificial intelligence in agriculture

Traditional farming involves various manual processes. Implementing AI models can have many advantages in this respect. By complementing already adopted technologies, an intelligent agriculture system can facilitate many tasks. AI can collect and process a data, while determining and initiating the best course of action. Here are some common use cases for AI in agriculture:

Optimizing automated irrigation systems

AI algorithms enable autonomous crop management. When combined with IoT (Internet of Things) sensors that monitor soil moisture levels and weather conditions, algorithms can decide in real-time how much water to provide to crops. An autonomous crop irrigation system is designed to conserve water while promoting sustainable agriculture and farming practices. AI in smart greenhouses optimizes plant growth by automatically adjusting temperature, humidity, and light levels based on real-time data.

Detecting leaks or damage to irrigation systems

AI plays a crucial role in detecting leaks in irrigation systems. By analyzing data, algorithms can identify patterns and anomalies that indicate potential leaks. Machine learning (ML) models can be trained to recognize specific signatures of leaks, such as changes in water flow or pressure. Real-time monitoring and analysis enable early detection, preventing water waste together with potential crop damage.AI also incorporates weather data alongside crop water requirements to identify areas with excessive water usage. By automating leak detection and providing alerts, AI technology enhances water efficiency helping farmers conserve resources.

Crop and soil monitoring

AI allows farmers to easily make the necessary adjustments.While human observation is limited in its accuracy, computer vision models can monitor soil conditions to gather accurate data necessary for combatting crop diseases. This plant science data is then used to determine crop health, predict yields while flagging any particular issues. Plants start AI systems through sensors that detect their growth conditions, triggering automated adjustments to the environment.In practice, AI in agriculture and farming has been able to accurately track the stages of wheat growth and the ripeness of tomatoes with a degree of speed and accuracy no human can match.

Detecting disease and pests

As well as detecting soil quality and crop growth, computer vision can detect the presence of pests or diseases. This works by using AI in agriculture projects to scan images to find mold, rot, insects, or other threats to crop health. In conjunction with alert systems, this helps farmers to act quickly in order to exterminate pests or isolate crops to prevent the spread of disease.AI technology in agriculture has been used to detect apple black rot with an accuracy of over 90%. It can also identify insects like flies, bees, moths, etc., with the same degree of accuracy. However, researchers first needed to collect images of these insects to have the necessary size of the training data set to train the algorithm with.

Monitoring livestock health

AI can help todetects atypical cattle behavior and identifies activities such as birthing.CattleEye uses AI and ML solutions to determine the impact of diet alongside environmental conditions on livestock and provide valuable insights. This knowledge can help farmers improve the well-being of cattle to increase milk production.

Intelligent pesticide application

Applying pesticides manually offers increased precision in targeting specific areas, though it might be slow and difficult work. Automated pesticide spraying is quicker and less labor-intensive, but often lacks accuracy leading to environment contamination.AI-powered drones provide the best advantages of each approach while avoiding their drawbacks. Drones use computer vision to determine the amount of pesticide to be sprayed on each area. While still in infancy, this technology is rapidly becoming more precise.

Protecting crops

AI can monitor the state of plants to spot and predict diseases, identify and remove weeds, and recommend effective treatment of pests. For example, a precision agriculture startup called Taranis uses computer vision and machine learning to analyze high-resolution images of crops, providing plant insights to identify signs of stress or disease. Their AI-powered technologies can detect and classify diseases and pests with high accuracy. It can also suggest the most effective treatment for pests, reducing the need for broad-spectrum insecticides that can harm beneficial insects and lead to pesticide resistance.

Yield mapping and predictive analytics

Yield mapping uses ML algorithms to analyze large datasets in real time. This helps farmers understand the patterns and characteristics of their crops, allowing for better planning. By combining techniques like 3D mapping, data from sensors and drones, farmers can predict soil yields for specific crops.

Data is collected on multiple drone flights, enabling increasingly precise analysis with the use of algorithms. These methods permit the accurate prediction of future yields for specific crops, helping farmers know where and when to sow seeds as well as how to allocate resources for the best return on investment

Automatic weeding and harvesting

Similar to how computer vision can detect pests and diseases, it can also be used to detect weeds and invasive plant species. When combined with machine learning, computer vision analyzes the size, shape, and color of leaves to distinguish weeds from crops. Such solutions can be used to program robots that carry out robotic process automation (RPA) tasks, such as automatic weeding. In fact, such a robot has already been used effectively. As these technologies become more accessible, both weeding and harvesting crops could be carried out entirely by smart bots.

Sorting harvested produce

Most sorting processes are traditionally carried out manually however AI can sort produce more accurately. Computer vision can detect pests as well as disease in harvested crops. It can grade produce based on its shape, size, and color. This enables farmers to quickly separate produce into categories for example, to sell to different customers at different prices. In comparison, traditional manual sorting methods can be painstakingly labor-intensive.

Surveillance

Security is an important part of farm management. Farms are common targets for burglars, as it's hard for farmers to monitor their fields around the clock. Animals are another threat — whether it's foxes breaking into the chicken coop or a farmer's own livestock damaging crops or equipment. When combined with video surveillance systems, computer vision and ML can quickly identify security breaches. Some systems are even advanced enough to distinguish employees from unauthorized visitors

The Future of AI in Agriculture

Artificial Intelligence (AI) in agriculture is poised to grow significantly in the coming years, as it has the potential to revolutionize the sector by improving crop yields, reducing waste, and increasing efficiency. According to a report by MarketsandMarkets, the AI in agriculture market is predicted to experience explosive growth, with the market size expected to grow from $2.35 billion in 2020 to $10.83 billion by 2025 at a Compound Annual Growth Rate (CAGR) of 35.6% during the forecast period.

Collecting and analyzing large amounts of data is among the most notable advantages of AI in agriculture for farmers. This will lead to more informed decision-making and improved crop yields, essential for addressing the global food security challenge. Farmers can also use AI to monitor soil conditions, crop growth, and climate changes. As a result, they will be able to detect diseases early and take the necessary preventive measures before a crop is destroyed. AI will also continue to aid in forecasting weather changes, allowing farmers to plan their activities better and to take advantage of the optimal planting season.

Furthermore, AI can also help to reduce waste and resource usage. For example, farmers can use AI to optimize the amount of fertilizer and water used on their crops, leading to a more sustainable and environmentally friendly practice. This optimization will reduce the risk of soil and water contamination, which is an increasing concern today.

Conclusion

Applications of AI based tools in agriculture have initiated in India by several start-ups working in this area to help farmers with improved productivity and profitability from agriculture. While the benefits of AI in agriculture are numerous, the reality is that most farmers worldwide, particularly smallholder farmers, lack the necessary resources to implement these technologies. Smallholder farmers typically have limited access to technical training, which makes it difficult for them to operate AI systems effectively. Many also lack the financial resources needed to purchase the equipment and software required for AI-based farming. The adoption of AI in agriculture must be inclusive, considering the needs and limitations of smallholder farmers, who make up a significant portion of the global agricultural workforce. Initiatives that provide access to training and funding for smallholder farmers to implement AI-based farming practices can help bridge the divide. With this, farmers at all levels can benefit from emerging technologies that the world needs to secure our food system's future.

References

T. Bakker, K. van Asselt, J. Bontsema, J. Müller, G. van Straten. 2006.An autonomous weeding robot for organic farming.Field and Service Robotics , pp. 579-590

S. Choudhary, V. Gaurav, A. Singh, S. Agarwal.2019.Autonomous crop irrigation system using artificial intelligence.International Journal of Engineering and Advanced Technology., 8 (5S) pp. 46-51

https://www.jiva.ag/blog/how-artificial-intelligence-can-be-used-in-agriculture

https://www.agriculture.com/technology/robotics/the-future-of-robotic-weeders

https://www.khetivyapar.com/en/intelligence-ai-and-technological-advancements-future-of-farming-37

Volume: 04 Issue No: 12

UNDERUTILISED FRUITS POTENTIAL TOWARDS NUTRITIONAL SECURITY: WEALTH FOR INDIA'S FUTURE

Article ID: AG-VO4-I12-151

***R.Vinoth[1], A. Thanga Hemavathy[2], S. Kavitha[3] and Mohamed Yaseen.S. K[4]**

[1]Teaching Assistant (PBG), IOA, TNAU, Kumulur, Trichy, Tamil Nadu, India

[2]Assocaite Professor, Department of Pulses, TNAU, Coimbatore, Tamil Nadu, India

[3]Associate Professor, Centre for Students Welfare, TNAU, Coimbatore, Tamil Nadu, India

[4]Ph.D. Scholar, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

*Corresponding Author Email ID: rvinothagri@gmail.com

Introduction

Fruit crops play an important role in meeting the nutritional requirement with maximum value addition and foreign exchange earnings. India is a second largest producer of the fruits in the world with a production of 88 million tons (Anonymous, 2014). Post-harvest losses in fruits are very high (20-40%), about 10-15% fresh fruits shrivel and stale, lowering their market value and consumer acceptability. By improving the value addition we can increase the supply without increasing the land on cultivation. Species that have traditionally been used for food, fibre, fodder, oil, or medicinal purposes are among the underutilized fruit crops. Those species, on the other hand, have untapped potential to provide food security, nutrition, health, income, and environmental services. Fruits such as jackfruit, bael, jamun, karonda, phalsa, custard apple, wood apple, lasora, and others that are underutilized are major sources of livelihood for the poor and help to combat malnutrition (Gajanana et al., 2010). Fruit crops that are underutilized are mostly high in antioxidants and nutrients. Due to the significant level of astringency and acidic character of the fruits, these crops are not widely known. Diversification and popularization of such underutilized fruit crops are urgently needed. This can be accomplished by establishing appropriate processing and marketing methods for these minor fruits, such as transforming them into a variety of products.

Underutilized fruit crops can be defined as fruit crops which are have value but not widely grown, rarely found in the market and not cultivated commercially. The underutilized foods can also be defined as the foods which are less available, less utilized or rarely used or region specific. It is difficult to precisely define which attributes make a crop "underutilized", but often they display the following features:

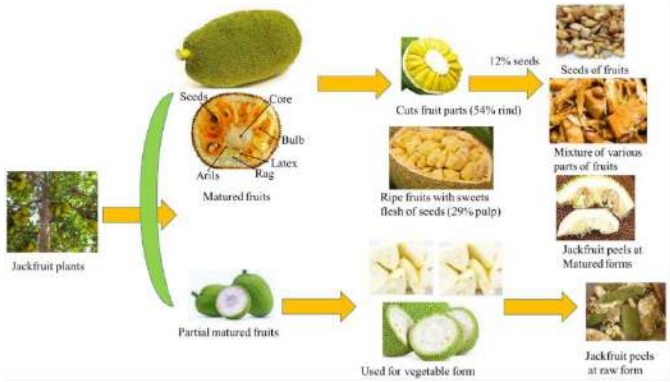
- Adaptation to specific agroecological niches and marginal land
- Weak or no formal seed supply systems
- Traditional uses in localized areas
- Produced in traditional production systems with little or no external inputs
- Receive little attention from research, extension services, policy and decision makers, donors, technology providers and consumers
- May be highly nutritious and/or have medicinal properties or other multiple uses

However, some of these fruits are not acceptable in the market in fresh form due to their acidic nature, unpleasant flavor, typical strong aroma, highly perishable nature, strong fruity aroma, sour sweet tastes, astringent taste, high percentage of tannin, presence of oily substance, hardshell, mucilagenous texture, numerous seed, thickened, sour and glutinous sepals. Hence, there is a need to less-known/under-utilized fruit species which have the potential for commercial exploitation are yet to be utilized to their potential. This, to some extent, can be achieved through developing suitable processing and marketing strategies for these underutilized fruits.

Therefore to ensure the production of the above mentioned minor/underutilized fruit crops there is a dire need to explore the possibility of utilizing these fruits in processing industries. There is a great scope of food processing and value addition to the underutilized fruits into a range of highly acceptable fruit products as mentioned in below.

JACK FRUIT *(Artocarpus heterophyllus*)

World’s largest fruit, belonging to the family Moraceae and is an important indigenous tropical fruit crop of India. It is very popular in Eastern and Southern parts of India. Ripe fruit is laxative, restorative, cooling, fattening and useful in treating biliousness . The plant is reported to possess anti-bacterial, anti-inflammatory, anti-diabetic, antioxidant and immuno-modulatory properties.



However, jackfruits are processed in to a number of food products like RTS, Squash, jam , jelly, chutney , chips, nectar , preserves ,confections , green jackfruit utilized for making pickle in oil and pickle in vinegar, canned vegetables, papad, leather, jackflakes can be bottled. Jackfruit seed can be processed in to flour. Unripe green fruit employed like a vegetable in the preparation known as 'Kathal sabzi' insome north Indian states.

JAMUN (Syzygium cumini)

Jamun is an important indigenous fruits of India. . Jamun trees are found scattered throughout the tropical and subtropical regions but there is no organised orcharding of this fruit in the country. It is popular as a desert fruit because of its slight astringent taste and big sized seeds. Jamun fruit is highly perishable and seasonal in nature. Considerable losses occur in this fruit during harvesting.

However, Jamun are processed in to a number of fruit products like quality beverages such as nectar, squash, syrup would be more nutritious than many of the synthetic drinks. It is reported that the ripe fruits are used for health drinks, making preserves, vinegar jellies and wine. It is reported that white-fleshed jamun has adequate pectin and makes a very stiff jelly.

AONLA *(Emblica officinalis*)

Aonla also known as Indian gooseberry belongs to family Euphorbiaceae. It is one of the most important minor fruit which has some commercial importance. The plant is quite hardy and prolific bearer giving high profitable returns, although it is the most neglected crop. Fruits are rich source of vitamin 'C'. The stability of ascorbic acid and presence of astringency in aonla fruit is due to the presence of polyphenols.

The fruit has also fair amount of iron, calcium and lysine . Aonla fruit is highly valued among indigenous medicines. It is acrid, cooling, refrigerant, diuretic and laxative. Dried fruits have been reported to be useful in haemorrhages, diarrhoea, dysentery, anaemia, jaundice, dyspepsia and cough. However, aonla fruits are processed in to a number of food products like Pulp, RTS, Nctar, Squash, Syrup, Herbalsyrup, Jam, Herbal, Jam, Toffee, Sauce, Candy preserve, shreds, pickle, Aonla sweets, Aonla powder, Diabetes powder, Trifla powder.

PHALSA *(Grewia Subinequalis)*

Phalsa belongs to Tiliaceae family and native to India. Fruits of phalsa are acidic, good source of vitamin A, ascorbic acid and also rich in various other nutrients. The fruit is astringent and stomachic. It is rated very high in indigenous system of medicine. It has been reported that when unripe, phalsa fruit alleviates inflammation and is administered respiratory, cardiac and blood disorders, as well as in fever reduction. Being highly perishable, the fruit must be utilized within 24 hours after picking.

However, Karonda are processed in to a number of food products like fruits are used for making excellent juice, RTS ,nectar ,squash, syrup and crush having cooling effect on the body .

BAEL FRUIT (*Aegle Marmelos)*

Bael is indigenous to India. The fruit is very nutritive and contains fair amount of vitamin-A , vitamin-B, vitamin-C, minerals and high carbohydrates content. The fruit is very rich in Riboflavin (Vitamin B_2).The bael fruit pulp contains many functional and bioactive compounds such as carotenoids, phenolics, alkaloids, coumarins, flavonoids, and terpenoids and has innumerable traditional medicinal use. Bael fruit is not popular as a desert fruit due to its hardshell, mucilagenous texture and numerous seed. It has good processing attributes such as excellent flavour, nutritive and therapeutic values.

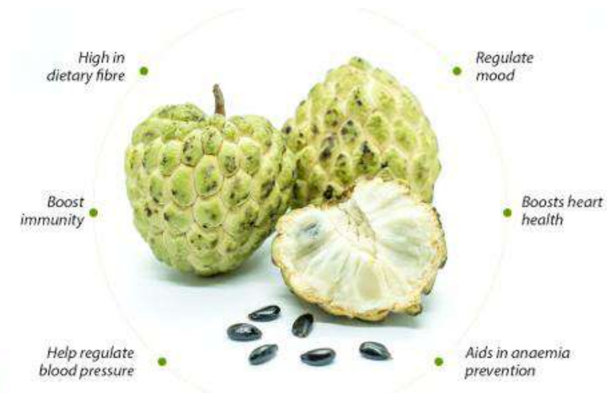
However, Bael are processed in to a number of food products like RTS, Nectar, Squash , Syrup , candy , preserve , Jam , leather/slab, powder , Fruit powder can be stored for a year when packed in 400 gauge polypropelene pouches and stored under dark, cool place, while fruit jam, squash and preserve can be stored for several months .

CUSTARD APPLE *(Annona Squamosa)*

Custard apple is one of the most delicious fruit plants of tropical and sub-tropical areas and belongs to Annonaceae family. In India, the fruits are eaten mainly by the lower and medium class people. Custard apple is highly perishable and cannot be stored for long time. The fruit has the tendency to burst open if kept on the tree for a long time.

The fruit is very sweet and delicious hence is used for table purpose. When fully ripe, it is soft to touch and easily pulled out. The flesh may be scooped from the skin and eaten as is or served with light cream and a springing of sugar.

However , Custard apple can be processed into number of fruit products like shakes or smoothes or even into natural ice creams , RTS, Squash, nectar, Syrup, jam, jelly, fermented alcoholic beverages, custard apple milkshake , natural ice cream , pulp can be supplied to the ice cream industries.



LASOORA *(Cordia myxa)*

Lasoora locally known as Gonda, Lasora or lehsua belongs to Boraginaceae family. It grows throughout India except in high hills and temperate climate. It is a perennial, medium sized tree with crooked stem. It bears small sized fruits in bunches, used in traditional vegetable and pickles. Fruits are considered as one of richest natural sources of antioxidants i.e. carotenoids, ascorbic acid, phenols etc.

However, lasoora are processed in to a number of fruit products like Immature green fruits are used as vegetable, Chutney and pickles. Sometime fruits are dehydrated after blanching for used as vegetable during off season.

FIG *(Ficus carica)*

It is a highly nutritious fruit consisting of 84% pulp and 16% skin. Besides, the fruit also contains protein, calcium, iron, vitamin A and thiamine at varying concentrations. However , Fresh figs are nutritious and used as dessert or for making jam, jelly, pudding, cakes, dried, preserved, candied or canned.

TAMARIND *(Tamarindus indica)*

It is a large sized, long-lived evergreen tall tree with a spreading crown. It is an excellent tree for social forestry and agro forestry. This crop is highly suitable for wastelands due to its multi ferrous uses and capacity to withstand adverse agro-climatic conditions. The fruit of tamarind a pod 5 to 15 cm long, 3 to 10 seeds surrounded with edible pulp which is principal souring agent for sauces, chutney, in beverages and in general cooking. It is also used in drying and tanning and for polishing and cleaning metal ware.The polysaccharide (jellose) is extracted from seeds, which is used as a sizing material in the cotton and jute industries.The bark and leaves are used for tanning.


THE WOOD APPLE ***(Limonia acidissimia)***

The wood apple is also known by many different names such as kainth and monkey fruit. The fruit is not under regular orcharding, however along the border of fields, roads, railways lines and as a roadside tree, near villages and banks of river are the most common places where the plants are found as stray plant. It is a climacteric fruit, ripening may also take place after fruit is harvested. It is well known for its quality and storage life, which helps avoiding the waste of raw material.

Wood apple is used in the preparation of chutneys and for making jelly and jam . Fruit bar is a nutritious product, has a chewy texture, similar to dried raisins and is a good source of dietar fibre and natural sugar. Wood apple juice when mixed with other fruits can serve as an excellent beverage.Realizing the importance of wood apple fruit as a significant contributor to human well being, as a cheaper and better source of protective foods; its perishable nature and seasonality in production calls for preservation of it to be supplied throughout the year for human consumption.


CARAMBOLA ***(Averrhoa carambola)***

Two cultivars sour and sweet depending on their taste are grown in our country. The tree is medium sized, attractive and evergreen growing to about 10m. The fruit of Carambola is a rich source of reducing sugars, ascorbic acid and minerals such as K, Ca, Mg and P. Oxalic acid and tannin are considered to influence taste strongly.

However, carambola are processed in to a number of food products like RTS, Nectar, Squash , Syrup, candy, preserve , The fruit can be eaten fresh and is often used in salads and as a Garnishing of cake due to its unique star shape.

For making sweet-sour dishes, dalma & curry, Used for flavouring fish , used as vegetable, Can be used as pickle.

ELEPHANT APPLE *(Dillenia indica)*

Elephant Apple is a deciduous tree of moderate size with It bears a large and hard fruit of 3-5 inches in diameter consisting of 5 closely fitted imbricate sepals enclosing numerous seeds embedded in a glutinous pulp.It is rich in protein, carbohydrate, fat and fibre with fairly high amount of calcium, phosphorus and energy value of 59 Kcal per 100g .It is generally not popular because of its thickened, sour and glutinous sepals. It has good processing attributes because of its flavour, sourness, nutritive and therapeutic values.

However, Elephant foot apple are processed in to a number of fruit products like Pickles, sauces, jams ,jelly & RTS beverages ,Sweet-sour dishes, dalma & curry, Dried product , Residual Osmo-syrup ,Osmo-dehydrated products, Used for flavouring fish.

KARONDA *(Carissa carandas*)

The karonda is a nontraditional fruit crop which thrives well as a rainfed crop. It can be grown as a hedge for beautification of nursery or orchard which serves as bio fencing material because of thorny nature. Karonda is a richest source of iron (39.1%) and also contain appreciable amount of proteins and fats. Fruits are astringent, anti ascorbic and used as a remedy for biliousness. Karonda is a hardy, evergreen, spiny and indigenous shrub which thrives well as rainfed crop. Fruits, sour and astringent in taste, are a very rich in iron , contains a good amount of vitamin C. They also contains protein, carbohydrates, fat, fibre and calcium.

However, Karonda are processed in to a number of fruit products like Candy, preserve , pickle, chutney, jam, RTS ,Nectar , squash ,syrup, dried raisins , tarts ,the ripened fruits may be eaten as dessert or used for the preparation of jelly, sauce, carissa cream or jellied salad. Unripe fruits are used for making pickles, sauces and chutney. The dried fruits may act as a substitute for raisins. The wine prepared from ripe fruits contains about 14.5 to 15% alcohol and is very much liked by wine fanciers Nalawadi

Conclusion

Most of the minor fruits are enriched with nutritional and medicinal value, and can be grown even in wastelands without much care. Therefore, it is worthwhile to look into the organized cultivation and improvement of minor group of crops like aonla, wood apple, bael, ber, phalsa, karonda ,bael, woodapple etc. so that their utilization can be maximized. Minor fruits are the future of horticulture in the twenty-first century, since they can provide a multitude of benefits in terms of profitability, productivity, sustainability, crop quality, food safety, environmental protection, and rural economic development. A considerable section of the rural population relies on locally available fruits to supplement their nutrition. These fruit crops have a long history of use, and the locals are well aware of their nutritional and therapeutic benefits.

The potentiality of processed products from some minor fruits in the country is still untapped. However, efforts have been made by various researchers for the development of value added products from underutilized fruits as explained above. Minor fruits are the future for horticulture of 21st century as this offer a variety of potential benefits in profitability, productivity, sustainability, crop quality, food safety, environmental protection and rural economic development.

References

Anonymous, 2014. Indian Horticulture Data Base. National Horticulture Board, Ministry of Agriculture, Government of India.

Gajanana, T. M., Gowda, I. N. D. and Reddy, B. M. C. 2010. Exploring market potential and developing linkages-A case of underutilized fruit products in India. Agricultural economics research review, 23: 437-443.

Gopalan, C.B.V., Rama Sastri and Balasubramanian, 1971. Nutritive Value of Indian Food, National Institute of Nutrition, ICMR, Hyderabad, India.

Jadhav, S. B., Joshi, G. D. and Garande, V. K. 2004. Studies on preparation and storage of karonda (Carissa carandas Linn.) fruit products. Beverage Food World, 31 (5): 46- 47.

Mala, R. 2009. Nutrient content of important fruit trees from arid zone of Rajasthan. Journal of Horticulture, 1 (7): 103-108.

Singh, I. S. 2001. Minor fruits and their uses. Indian Journal of Horticulture, 58: 178-182.

Tiwari, A. K. and Vidhyarthi, A. S. 2012. Jackfruit Jam: Preparation, nutritive values and storage stability. Pharmbit, 1-2.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

BIOMETRICAL GENETICS IN PLANT BREEDING

Article ID: AG-VO4-I12-152

K Subhasri and Narkhede Gopal Wasudeo*

Department of Genetics and Plant Breeding

School of Agriculture, SR University, Warangal – 506371, Telangana, India

*Corresponding Author Email ID: n.gopalwasudeo@sru.edu.in

Introduction

Biometrical genetics or quantitative genetics is vital for better crop variety generation. It involves features controlled by multiple genes most of which are modifiable by environment. This paper gives a complete review of the role that biometrical genetics plays in food production through fundamental ideas, methods, principles, applications of plant breeding, and current developments.

Principles of Biometrical Genetics

1. Quantitative Traits

Quantitative traits are determined by more than one gene, or polygenes, and they continuously vary within a population. An example of these involves plant height, yield, and more such as drought tolerance. Their complexities require statistical models in order to understand the effects of both environmental and genetic factors.

2. Genetic Variance Components

The phenotypic variance of quantitative traits is decomposed into several components:

- **Additive Genetic Variance (VA):** This is the percentage of genetic variation that can be assigned to allele additive effects. Because VA is heritable and hence subject to selection, it is important.
- **Dominance Genetic Variance (VD):** The interactions between the alleles at specific locations cause this variance. Compared to additive variance, it is often less immediately beneficial for selection and is more difficult to assess.

- **Interaction Variance (VI):** Variation brought about by allele interactions at various loci (epistasis). Although it can make predicting trait performance more difficult, this is necessary to comprehend the entire genetic architecture.
- **Environmental Variance (VE):** the percentage of variation that can be attributed to external factors. This element emphasizes how crucial environmental factors are for the expression of traits.
- **Genotype-by-Environment Interaction (GxE):** This illustrates how distinct genotypes react to fluctuations in the environment in different ways, influencing the performance and stability of traits.
- **3. Heritability**

Heritability quantifies the proportion of phenotypic variance due to genetic variance. It is divided into:

- **Broad-Sense Heritability (H^2):** It encompasses all genetic contributions, including dominance, interaction, and additive effects.
- **Narrow-Sense Heritability (h^2):** It expresses additive genetic variance in particular. A high narrow-sense heritability indicates that selection can successfully increase a trait.

4. Selection Methods

- **Mass Selection:** Utilizing individuals chosen for continued breeding based on their phenotypic. This approach is less accurate yet simpler.
- **Pedigree Selection:** involves choosing plants according on their lineage and offspring's performance, offering a more comprehensive method.
- **Progeny Testing:** Evaluating offspring to determine the genetic potential of parents, allowing more accurate selection for desirable traits.

Methodologies in Biometrical Genetics

1. Quantitative Trait Locus (QTL) Mapping

QTL mapping locates genomic areas linked to quantitative traits. Through the correlation of genetic markers with phenotypic data, researchers are able to identify QTLs and determine how they affect trait variation.

- **Linkage Mapping:** Makes use of genetic markers connected to the desired characteristics. The efficiency of this approach may be constrained by the resolution and density of marker.

- **Association Mapping:** It is sometimes referred to as genome-wide association studies (GWAS) as it links genetic variants throughout the entire genome to phenotypic variations. This method finds QTLs more precisely and has a higher resolution.

2. Marker-Assisted Selection (MAS)

To aid in selection, MAS uses molecular markers associated with desired characteristics. By facilitating early selection before the trait is phenotypically displayed, this strategy speeds up breeding.

Application: Breeding for disease resistance, quality enhancement, and stress tolerance has made considerable use of MAS. For example, resistant cultivars of rice and wheat have been developed as a result of markers for disease resistance.

3. Genomic Selection (GS)

Genomic Selection predicts an individual's genetic value by using high-density marker data. This approach takes into account the effects of all markers at once, giving an improved understanding of the genetic potential.

Implementation: GS uses pre-existing genotype-phenotype data to train models that forecast the breeding values of untested individuals. This method works especially well for traits with intricate genetic structures, and it has been effectively used in the breeding of wheat and maize.

4. Environmental Interaction Studies

Identifying stable genotypes that function consistently in a variety of settings is made easier by analyzing genotype-by-environment interactions. This is essential for developing types that are environment-adaptable.

Approach: Genotypes with stable performance can be chosen with the aid of statistical models that take GxE interactions into account. Studies conducted on crops such as barley and soybeans have shown cultivars that exhibit outstanding yields under many environmental circumstances.

Applications in Plant Breeding

1. Yield Improvement

One of the main objectives of plant breeding is to increase the yield of crops. Tools for identifying and choosing for characteristics linked to increased yield, such as seed size, plant architecture, and grain number, are provided by biometrical genetics. High-yielding cultivars of crops including rice, wheat, and maize have been developed primarily due to advances in QTL mapping and MAS.

2. Disease Resistance

Crop productivity and health depend heavily on disease resistance. Through QTL identification and MAS, breeders may develop variants that are resistant to key diseases. For example, by identifying resistance genes connected to particular pathogens, research has resulted in the development of wheat cultivars resistant to disease.

3. Abiotic Stress Tolerance

Abiotic stresses that can significantly affect agricultural productivity include salinity, drought, and high temperatures. The identification and selection of traits conferring tolerance to these stresses is aided by biometrical genetics. Research has found QTLs in wheat and rice that confer resistance to drought, allowing for the development of cultivars that are more resilient to adverse weather.

4. Quality Traits

Enhancing quality attributes including flavor, texture, and nutritional value is another important part of plant breeding. To comprehend the genetic basis of these characteristics and make modifications, biometrical methodologies are employed. For example, utilizing marker-assisted techniques, soybean breeding has concentrated on increasing oil content and protein levels.

Recent Advancements and Future Directions

1. Integration of Omics Technologies

A comprehensive understanding of the genetic and molecular processes underpinning quantitative characteristics is provided by the combination of genomes, transcriptomics, proteomics, and metabolomics. By using a multi-omics method, we can better comprehend trait architecture and increase breeding prediction accuracy.

Example: Integrating transcriptome and genomic data has improved the analysis of the gene networks involved in stress responses and offered new perspectives on how stress-resistant cultivars might be developed.

2. Advances in Statistical Models

Complex trait analysis has been enhanced by recent advances in statistical models, including machine learning techniques and Bayesian approaches. Large datasets and intricate interactions can be handled by these models with greater proficiency, producing more precise predictions and superior selection results.

3. Climate Change Adaptation

Varieties that can adapt to changing conditions are needed as climate change presents novel challenges to agriculture. In order to develop crops that are resistant to climate change, biometrical genetics will be essential in detecting and selecting for traits such as heat tolerance, drought tolerance, and nutrient efficiency.

4. Ethical and Environmental Considerations

There are ethically and environmental issues with the application of cutting edge genetic technologies. It is necessary to address issues including genetic alteration, biodiversity, and the possible effects on non-target species. Plant breeding procedures must be carried out ethically, and innovations must guarantee the sustainability of agriculture and the health of ecosystems.

Conclusion

The basis of contemporary plant breeding is biometrical genetics, which offers vital resources and techniques for enhancing crop varieties. Breeders may develop plants with improved yield, disease resistance, stress tolerance, and quality by studying quantitative attributes, applying MAS, QTL mapping, and genomic selection, and analyzing environmental interactions. Our capacity to handle complicated characteristics and adjust to changing environmental situations is being further strengthened by recent developments in omics technologies and statistical models. Plant breeding will be essential to supplying the world's food needs and advancing sustainable agricultural methods as it develops further.

References

Carter, T. L., et al. (2018). Genetic improvement of soybean quality traits through marker-assisted selection. Journal of Crop Improvement; 32(3): 245-263.

Carter, T. L., et al. (2020). Stable Yield Performance of Soybean Genotypes Across Diverse Environments. Field Crops Research; 253: 107804.

He, Y., et al. (2022). Marker-Assisted Selection for Disease Resistance in Major Crops: A Review. Crop Science 62(4): 1598-1612.

Huang, X., et al. (2021). QTL Mapping and Genomic Selection for Drought Tolerance in Rice. Rice; 14(1): 40.

Kang, M. S., et al. (2022). Advances in Statistical Models for Complex Traits: Applications in Plant Breeding. Journal of Plant Breeding and Crop Science; 14(3): 245-259.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

BENEFICIAL BACTERIAL SIDEROPHORES

Article ID: AG-VO4-I12-153

M.Paramasivan[1*], I Johnson[2], Asish.K.Binodh[3] and V.Ravichandran[1]

[1*]Associate Professor, (Plant Pathology), Regional Research Station, TNAU, Vridhachalam

[2]Associate Professor, (Plant Pathology), Department of Plant Pathology, TNAU, Coimbatore

[3]Associate Professor, (PBG), CPBG TNAU, Coimbatore, Tamil Nadu, India

*Corresponding Author Email ID: paramasivan.m@tnau.ac.in

Introduction

Siderophores are small high affinity chelating compounds secreted by bacteria, fungi and some grasses. Fluorescence Pseudomonas have been recognized as biocontrol agents against certain soil borne plant pathogens. They are characterized by Production of yellow green pigments termed Pyoverdins which fluoresces under UV light and function as siderophores. Pyoverdins chelate iron is rhizosphere and deprive pathogens of Fe (iron) which is required for the growth and pathogenesis of pathogens.

Table: Siderophores producing bacterial biocontrol agents

S.No.	Siderophores	Producing Organism
1.	Pyoverdins	*Pseudomomnas fluorescens, P.putida, P.Syringae*
2.	Agrobactin	Agrobactrium tunefacines
3.	Cheysobactin	Ervinina chrysantheni
4.	Enterobactin	Enterobacteriaceae
5.	Aerobactin	Ervinina carotovora
6.	Ferioxomine-E	Streptomyces spp, Erwinina herbicola
7.	Rhizobactin	Rhizobium meliooti

A number of fluorescens Pseudomonas which biocontrol activity against *R. solancerum* causing bacterial wilt disease in solanaces have been reported. Siderophores are well-recognized iron-chelating agents produced by numerous microbes and are associated with the rhizosphere.

These siderophore-producing microbes are eco-friendly and sustainable agents, which may be managing plant stresses in the degraded land by (Singh *et al*., 2022)

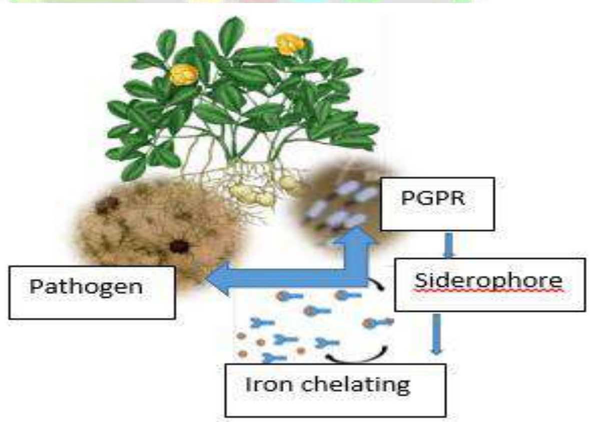
Iron is a vital element for plant and microbial growth; yet, the major portion of iron in soils is in the form of (oxi-) hydroxides with limited bioavailability, resulting in decreased crop yield quality. In response to iron deficiency, soil microorganisms produce siderophores that transform insoluble iron into a soluble form that plants and microorganisms can use. The abundance and activity of siderophore-producing bacteria (SPB) might be used as a biological assessment index for the fertility status of cultivated land. In order to achieve this goal, it is critical to investigate the influences of SPB on plant growth and soil quality by zhang et al., 2023

In Plants Fe is an indiscriminate consumable nutrient. it play an essential role in respiration, N2 fixations, DNA, Chlorophyll synthesis, and other enzymatic systems.

Mechanism:

To cope up with extreme Fe deficiency for microorganism developed a high affinity system for ferric transport which consist of two compound.

1. Secreation of Siderophores Fe iron regulated and low molecular weight ferric specific chelates
2. Elaboration of membrane repair molecules which bind siderophores and transport them in to the cell.



Conclusion

Siderophores can help plants by: Reducing iron deficiency, Enhancing physiological and biochemical processes, Promoting seed germination, Promoting plant growth, and Enhancing soil health. Other bacteria producing siderophores are Azotobacter, Azospirillum, Bacillus, Enterobacter, Klebsiella, Methylobacterium, Pantoea, Paenibacillus, Rhodococcus, Serratia.

Reference

Singh P, Chauhan PK, Upadhyay SK, Singh RK, Dwivedi P, Wang J, Jain D and Jiang M .2022 Mechanistic Insights and Potential Use of Siderophores Producing Microbes in Rhizosphere for Mitigation of Stress in Plants Grown in Degraded Land. *Front. Microbiol.* 13:898979. doi: 10.3389/fmicb.2022.898979.

Zhang, S. Deng, Z. Borham, A. Ma, Y. Wang, Y. Hu, J. Wang, J. Bohu, T.2023. Significance of Soil Siderophore-Producing Bacteria in Evaluation and Elevation of Crop Yield. *Horticulturae* **,** *9*,:370. https://doi.org/10.3390/horticulturae9030370

Volume: 04 Issue No: 12

THE ROLE OF IOT AND AI IN TRANSFORMING AGRICULTURE

Article ID: AG-VO4-I12-154

***Kishore S. M[1] and Chunchu Suchith Kumar[2]**

[1]Ph.D Scholar, Entomology. Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences- Shivamogga-577204

[2]Assistant Professor, Department of Agronomy, School of Agriculture, SR University, Warangal, Telangana-506371, India

*Corresponding Author Email ID: kp464751@gmail.com

Introduction

Peculiar to the growing world, Artificial Intelligence (AI) and Internet of Things (IoT) are rapidly transforming industries, not exempting agriculture. The integration of AI and IoT has paved way to smart, efficient, productive and sustainable farming. IoT systems when supported by AI to assist farmers in real-time, data management, resource efficiency and agricultural yields with little effect on the environment. It is a credible potential that these technologies can help the agriculture business tackle some of the biggest problems that it currently encountering for instance; climatic change, inadequate supply of inputs and the increasing global population.

In farm operations, AI has been applied to increase automation, in decision making as well as the utilization of resources including water, fertilizers and labour. In the meantime, realized through devices, sensors and machines, IoT agriculture impacts the field by improving farming processes. The above technological innovations are revolutionizing agricultural sector and assisting farmers to address current challenges.

Benefits of Implementing IoT in Agriculture

1. The Possible Way of Elevating the Efficiency and the Productivity

Iot is able to boost the optimum yield in the agricultural sector through enhancement of efficiency. Most of the farming activities require IoT systems where the machines and equipment are used to minimize on the workers and inputs.

For example, IoT irrigation systems used in farming ensure real time monitoring of soil moisture conditions and control of water supply, thus minimising wastage. Likewise, livestock monitoring systems help farmers to monitor the heath of the animals, the moment they get sick, necessary action is taken to address the problem to avoid lots of loss. Efficiency is achieved through the elimination of repetitive tasks leaving the farmer to handle more important issues that contribute to enhanced farming productivity.

2. Precision Agriculture & Resource management

Drones and different sensors let farmers keep track of different points of their fields, like soil quality, crop state, climate conditions, etc. Such precision makes it possible to apply the required amount of resources such as water fertilizer and pesticide without wastage hence cutting on the expenses.

Through remote monitoring techniques such as soil moisture sensors (SMPS) and Variable Rate Irrigation (VRI) systems, farmers will be able to vary the irrigation schedules and fertilizer application to meet the needs of the crop availing itself in the farm. It also minimizes the amount of waste produced thus contributing to the government's vision of sustainable agriculture.

3. Real time monitoring and using accurate data in decision making

Many IoT sensors allow the storage and collection of a large amount of environmental data such as temperature, humidity, soil pH and much more. This data is in real-time and farmers quickly make the right decisions that impact on the yields as discussed below.

For instance, a farmer can control a setting in a greenhouse he/she is not physically present in through a mobile application and alter the temperatures or humilities for proper plant growing. Live tracking allows the farmers to react immediately to situations that could cause a loss such as from pests, harsh weather or even inadequate care to crops.

4. Effectiveness and Efficiency Retention and Boosting-webpack

IoT can enhance operational costs because it operates a number of repetitive, labour bound tasks that if completed by workforce, may consume a lot of resources & cash. Also, IoT fuels Principal analysis for matters such as pests' outbreak or change in weather, whereby farmers are in a position to counteract and prevent.

IoT technologies help the farmers in increasing profitability of the farming processes by decreasing operation costs such as employment cost through mechanization, through efficient use of the resources and above all through increase in the yield of the crops. In turn, farms are able to get more from less, which increases the efficiency and yield on their investments.

5. For this reason, the next topic discusses ways to encourage environmental sustainability.

It is a common practice today to look at sustainability when practicing farming. The article shows how IoT contributes to sustainable agriculture. Smart farming, through IoT, ensures that inputs like water, fertilizers and pesticides is used as required avoiding excess and hence avert pollution.

IoT enabled smart greenhouses whose aim is to enhance climate control, cut energy usage and foster plant health. Temperature, humidity and light controls of these systems make use of energy in the most efficient way to reduce as much as possible the carbon imprint of farming.

Potential Internet of Things Technologies Impacting Agriculture

1. Uses of Sensor Networks for data Collection

The IoT sensors are essential for getting data regarding various aspects of agriculture which includes moisture, temperature and health of crops. These sensors can fill the high frequency data void and enable farmers to make real-time decisions.

For instance, the CropX company offers soil moisture sensors that help control the application of water to the crops because its level in the soil is controlled. With the capability of cutting down water usage in half these sensor aids in high crop yields with less harm to the environment.

2. The issue of drones in farming: Uses of agricultural drones and aerial photography

Even when multispectral cameras are mounted on agricultural drones, crop monitoring is on the process of being transformed. For instance, the SenseFly's eBee SQ can evaluate general health of the crops and therefore, determine areas that may require a close check.

Drones can also spray seeds, control pests and even water the crops since such duties in the past used to be done by hand. These UAVS minimize the time taken in farming, conserved resources and increases efficiency of farming activities thus improving the quality and yields.

3. Applications of Robotics and Automation in Farming Activities

There is a growing application of robotics to such activities as sowing, harvesting, as well as weeding. Hence, with such platforms such as unmanned tractors that have been developed by Eco Robotics, farmers can plant seeds, weed and even spray crops automously.

These robots assist in minimizing ownership costs, costs of production, as well as relay a signal that large scale farming can be practiced without necessarily hiring more personnel. Consequently, automation plays the key role in increasing productivity as well as increasing the number of farms.

4. Internet of Things Platforms and Data Analytical Tools

There seem to be enhanced performance in IoT for agriculture through the data analytics platforms that handle the large volume of data collected by IoT sensors. Normally, data collected by these different sensors is then synthesized by other Apps such as FarmLogs which gives different analyses including yield expectations, irrigation requirements, and the quality of the soil.

By integrating AI and machine learning algorithms, these platforms help farmers predict harvest times, detect issues like pest outbreaks, and make more informed decisions. With these tools, farmers can optimize their operations and improve overall farm management.

Specific Examples of IoT in Agriculture

1. Precision Farming Techniques

Precise farming means the action with respect to agriculture based on accurate and verified data. Through IoT, farmers are able to determine the right time, amount of water, pesticides and fertilizers to use in order to improve crop yields without a negative impact on the environment.

For instance, in realising crop management, the sensors that quantify the moisture content of soil and its temperature are extremely important in estimating the periods of irrigation and applying fertilizer. Precision farming techniques save more costs thus increasing on the productivity of the farmers.

2. Soil Analysis and Management

IoT sensors can monitor real time condition of soil including moisture level, temperature of the soil, the pH of the soil and nutrient level in the soil. The data also assist farmers in determining requirements of the crops so as to focus on the areas of irrigation and fertility.

Examples of technology includes; crop metrics which help firms monitor soil moisture in order to water crops only when it is necessary. Thus, the approach assists in Cole saving and overall health of crops hence encouraging high yields.

3. Having ways on how to control crop health and growth

IoT devices could be used to watch the effects that climate has on crops, such as the amount of humidity, temperature and light. In this way, farmers are provided with indicators of diseases or pest invasions before these threats harm their crops even more.

For instance, Arable's field monitoring platforms will enable farmers to optimise output from fields as data is received continually and analysed. In this case, farmers can easily notice any changes in the environmental factors surrounding crops so that right amendments can be made in order to avoid loss making.

4. Results within Livestock Management

The same technologies are also being employed in the examinations of health and behaviour of cattle in farms. It also be used to track the animals, monitor their welfare, and even to monitor a health change early signs of an animal's sickness or injury. Using such information farmers can act fast and the results will be an improvement in animal treatment as well as the productivity of the farms.

Such IoT-based solutions as Cowlar let farmers to monitor the state of cows and respond to some issues. These systems can also be used to schedule the feeding too so that the animals are fed on the right time and with the right kind of food.

5. She performed a simulation using FECA, which stands for Automated Feeding and Care Systems.

Through use of IoT sensors in feeding the animals, it has been possible to develop programs in feeding that will see animals fed on the right time and food wasted is minimized. Through controlling health and behaviour of the animals, such systems make sure that each animal is provided with the food that is required.These vending feeders for animals can be connected to the health monitoring devices hence the ability to manage animal health wholly. This has implication that by engaging in this process in an automated way the cost of labour in farms can be minimized while increasing efficiency levels.

6. Smart Greenhouse Management

Smart greenhouses that are in connection with IoT use elements of automaticity in functions such as watering, ventilation, and lighting. These systems control the internal environment of the greenhouse thus maintaining the best environment for plant growth, and at the same time using as little energy as possible.For instance, in Farmapp, sensors control climatic factors such as the rate of air change, and the quality of light throughout the crop growing process to lower energy costs and increase crop output.: Most of the smart greenhouses are a move towards better sustainable and efficient farming systems.

7. Automated Irrigation Systems

IoT application has made it easier for the farmers to set irrigation procedures on time by use of data from the moisture on the soil. This makes water management possible, in that it avoids cases where the crops are given excess water or where they are not given enough water.Some of these IoT are offered by companies such as GreenIQ that avail options for managing irrigation so that farmers can save water and costs.

8. Supply Chain Optimization

Internet of things (IoT) is not only applicable to the functioning of the farm, but in all sectors related to agriculture too. Some of the utilizes of IoT in the context of industries include keeping track of stocks, quality of goods, and ways of moving goods from one place to another.

In this case, farmers can use IoT sensors to monitor their produce inventory and the logistics surrounding harvests which will help them minimize spoils, increase the quality of their products and increase their market potential. For instance, application such as Operations Centre enable farmers to manage the supply chain through acquisition of current inventory and transportation requirements information.

9. These are possibly the most strategic reasons as entrants ensure quality assurance and product traceability in a supply chain.

When connected to IoT, blockchain has the potential to support chain of custody for agricultural products. There is transparency achieved when a product is followed from the farm to the table so that a consumer can confirm the legitimacy of the source of food.

Walmart utilizes IBM Food Trust in providing information on products such as lettuce's supply chain and assists in rendering the food safe or of high quality.

Difficulties Facing the Implementation of IoT in Agriculture

1. Initial Investment and Cost Barriers are another sub-topic under the broader category of Entry-Mode-Strategy-Barriers that needs to be understood while going for an FDI.

The use of IoT in the agricultural sector implies a huge investment in the logistic and system setup. Indeed, it is evident that most of the small-scale farmers get stuck when it comes to sourcing for adequate capital to put into these technologies. Also, the costs of maintenance and licenses of other software used to support workflow also contributes to total costs.

2. Tactical Specificity as a Function of Technological Properties and Expert Skills

IoT systems are relatively complex and therefore the implementation and management of these systems entail some level of technical know-how. They can have difficulties in the calibration of the system, management of the devices as well as the diagnosis of the problems especially when system installation is done in the remote areas where it may be very hard to find qualified technical personnel.

3. Challenges in Data Security and Data Privacy

Given the fact that IoT systems are data centric, the challenge of data privacy and concerns around cybersecurity attacks are even more pressing. Some information that is pertinent in farming is Highly Sensitive in nature, therefore the need to protect it to the later most to enable farming be safe.

4. Inadequate Infrastructure and poor Connectivity

IoT systems require dependable Internet connections which can pose a challenge since many rural regions may not mount a strong network at all. Cases of situation where they fail to get real-time information transmitted from them back to inventors, due to instabilities in internet connection makes the use of IoT devices slightly compromised.

Trends to Look Forward to in Agricultural IoT

1. Inclusion on AI and Machine Learning

The use of AI and machine learning is going to remain a dominant part of the agricultural IoT's future. These technologies facilitate the possibility to solve problems in advance: diseases, pests, and unfavourable weather conditions.

2. Blockchain for Traceability

Blockchain technology will likely improve traceability of agricultural products, guaranteeing the secure information on origin and production methods of crops.

3. The Rise of Edge Computing

IoT will be benefited by edge computing technology as it shall improve real time data processing for particularly rural areas. This has made it possible to process data locally and thereby increase the rate of making decisions.

4. Sustainable innovation in Farming Machinery

The application of autonomous machinery means that new agricultural machinery that drives on its own such as, tractors, drones among others will help cut on costs and increase efficiency of farming. Some of these machines are capable of planting, weeding and harvesting without much external human interferences.

Conclusion

The use of IoT and AI within the sector is revolutionizing farming through efficiency augmented sustainability and optimal utilization of the resources available. There are certain disadvantages like in the first place the setup costs, intrinsic technical issues in implementing IoT and the issues regarding connectivity but on the positive side IoT has a lot of potential in agriculture. In this manner, those technologies will assume a significant function in meeting the needs of the increasing population of the world without jeopardizing the environment.

References

https://www.agrifarming.in/role-of-ai-and-iot-in-agriculture-a-full-guide#

Sharma, A., Sharma, A., Tselykh, A., Bozhenyuk, A., Choudhury, T., Alomar, M. A., & Sánchez-Chero, M. (2023). Artificial intelligence and internet of things oriented sustainable precision farming: Towards modern agriculture. Open Life Sciences, 18(1), 20220713.

AlZubi, A. A., & Galyna, K. (2023). Artificial Intelligence and Internet of Things for Sustainable Farming and Smart Agriculture. IEEE Access.

Wolfert, S., & Isakhanyan, G. (2022). Sustainable agriculture by the Internet of Things– A practitioner’s approach to monitor sustainability progress. Computers and Electronics in Agriculture, 200, 107226.

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 12

MEALYBUG DESTROYER *CRYPTOLAEMUS MONTROUZIERI* AN EFFECTIVE COCCINELLID PREDATOR FOR SUGARCANE CROWN MEALYBUG MANAGEMENT

Article ID: AG-VO4-I12-155

***M. Punithavalli[1], K.P. Salin[2], N. Geetha[2], T. Rajula shanthy[2] and C. Gokila[3]**

ICAR – Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, India

[1]Senior Scientist, ICAR - Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, India

[2]Principal Scientist, ICAR - Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, India

[3]C. Gokila, Young Professional – I, ICAR - Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, India

*Corresponding Author Email ID: bjaasritha14@gmail.com

Abstract

The crown mealybug, *Phenacoccus saccharifolii* (Hemiptera: Pseudococcidae), a sap-sucking pest, has recently emerged as a significant threat to sugarcane across several sugarcane-growing regions of Tamil Nadu. The crown mealybug infestation in sugarcane was initially observed in the Pugalur area of Karur district, with a severe outbreak later reported in the Sathamangalam, Ariyalur, and Erode districts of Tamil Nadu. The crown mealybug infestation was observed in sugarcane crops aged 5 to 6 months, with the incidence being more severe during the summer months of all seasons (May to September). While insecticides have been used to control the mealybug, biological control offers a promising alternative. In this study, we focused on the coccinellid predator, commonly known as the mealybug destroyer, collected from sugarcane fields affected by the crown mealybug. We investigated its feeding potential under *invitro* conditions to assess its viability as a biological control agent for managing the sugarcane crown mealybug.

Key words: Crown mealybug, sugarcane, *Cryptolaemus*, mass culturing, pumpkin

Introduction

The sugarcane ecosystem provides a highly suitable environment that supports a range of natural enemies of pests and diseases, making it an ideal location for biological control strategies.

The integration of biological control methods in sugarcane cultivation can reduce the reliance on chemical pesticides there by enhance soil health and reduce environmental impact. This article discusses the crown mealy bug, an emerging insect pest of sugarcane, and its effective biological control agent, the coccinellid predator *Cryptolaemus montrouzieri*. We collected *C. montrouzieri* from sugarcane fields and studied its feeding potential on the crown mealy bug under *invitro* conditions.

Crown mealybug

The nymphs and adults of the crown mealybug settle on the leaf sheaths near the crown region of the sugarcane plant, where they vigorously feed on the sap, causing distinct black necrotic scars on the leaves. Affected sugarcane plants exhibit severe yellowing, the growth of sooty mould, stunting, drying or rotting of the central whorl, failure to produce canes, excessive grassy tillering, and poor establishment of sprouted ratoons.

Affected sugarcane plants display a range of symptoms, starting with severe yellowing of the leaves, which significantly reduces the plant's overall vigor. The infestation also leads to coverage of leaf surface with sooty mould fungus that thrives on the honeydew secreted by the mealybugs, further reduces the photosynthesis. As the infestation progresses, the plants become stunted, the central whorl of the sugarcane begins to dry out or rot, preventing proper shoot development. The affected plants produce excessive grassy tillering, (abnormal number of shoots), diverting energy away from cane growth. Finally, the mealybug damage leads to the failure of cane production, reducing the yield potential. Moreover, the ratoons, fail to establish properly, causing long-term damage to the crop's productivity.

Crown mealy bug infestation (Co 09004)

Crown mealy bug attacked field

Crown mealybug spread on the leaf whorl of sugarcane

Crown mealy bug ovisac and nymphs of different stages

Crown mealy bug lays around 300 to 500 as loosely packed tubular ovisacs. The eggs were laid in batches within the same ovisac, forming clusters. Freshly laid eggs were pale yellow and oval-shaped. The freshly emerged crawlers were yellow, highly active, and moved in groups. The matured nymphs were yellow, soft-bodied, and completely covered in a white, powdery waxy coating. The waxy filaments were prominent all around the body, with noticeable protrusions observed in males. Males undergo a true pupal stage, whereas females develop into adults without undergoing metamorphosis. The well-matured females were stout, inactive, and whole the body covered with white waxy filaments. The ovisac of females was more than twice the size of the body. The females often crowded together, with their overlapping long ovisacs forming a cotton-bed-like appearance. The long body of the adult female became globular, wide at the posterior end with waxy projections. The females suck the sap from the leaves, resulting in distinct black necrotic scars on the leaves.

Management of crown mealy bug on sugarcane

Despite the availability of various chemical insecticides, complete control of crown mealybugs remains challenging due to their presence in the inner crown region of the leaf whorl. In this context, biological control is the only feasible alternative method to manage this notorious pest in sugarcane. *Cryptolaemus montrouzieri*, commonly known as the mealybug destroyer, has emerged as a promising predator for controlling sugarcane crown mealybug. During a survey of a sugarcane field infested with mealybugs, we collected grubs, pupae, and adults of *C. montrozieri* from the canes affected by crown mealybugs. Grubs in the first to third instar stages were commonly found in most crown mealybug colonies and effectively preyed on first, second, and third instar mealybugs.

***Cryptolaemus* grub on the leaf**

***Cryptolaemus* pupae on the leaf**

***Cryptolaemus* adults on the leaf**

The mealy bug predator *Cryptolaemus montrouzieri*

The adults are small brownish beetle, it lay eggs singly among the eggs sac of mealybugs and formed in patches. Freshly laid eggs are pale yellowish-white, with a smooth, shiny surface and an oval shape. As they mature, the eggs turn white. The incubation period for the eggs lasts between 5 to 7 days. The freshly emerged tiny grub was a pale grayish color with white lines running along the intra-segmental regions of its body. These white lines became more pronounced after a few hours, and white wax strands appeared after a day. The grub was flat, convex dorsally oval in shape and grayish in colour and 4 instars. Grownup grubs are entirely covered with white wax strands. The young grubs feed on eggs and small mealybugs, but as they mature, they become voracious and consume all life stages of mealybugs. Grub period lasts for 18-23 days. The matured grub pupates on both the adaxial and abaxial surfaces of sugarcane leaves. The prepupal stage lasts 2 to 4 days, while the pupal stage ranges from 7 to 9 days.

The newly emerged adults were soft and reddish-yellow in color. Males were smaller than females, with the first pair of legs brown and the other two pairs black, while in females, all three pairs of legs were black. The last abdominal segment of the male beetle was rounded, while in the female, it was pointed. Adults prey on all stages of mealybugs but are less voracious feeders compared to grubs. A single female lays between 60 to 130 eggs.

Mass multiplication of *Cryptolaemus montrozieri*

Croton mealybugs, *Planococcus citri* (Hemiptera: Pseudococcidae), were reared on pumpkins to mass-produce *Cryptolaemus montrouzieri* for managing crown mealybugs, *Phenacoccus saccharifolii*. Twenty-five pairs of adult *Cryptolaemus* were collected from mealybug-infested sugarcane fields and released onto pumpkins cultured with croton mealybugs. During the exposure period, the beetle feeds on mealybugs and lays its eggs either singly or in groups of 6 to 20. The young grubs initially feed on eggs and small mealy bugs, but as they mature, they become more voracious, consuming all stages of mealy bugs. The mature grubs were collected and placed in separate boxes containing sugarcane leaves to pupate. The adult *Cryptolaemus* beetles were collected, paired, and then released into fresh pumpkin cultured with croton mealy bugs.

Rearing of crotons mealybug –*Planococcus citri* on the pumpkin

***Cryptolaemus* adults released on the pumpkin for oviposition**

***C. montrozieri* Eggs**

***I^st^ Instar grubs of Cryptolaemus* on the pumkin**

Grown up grubs on the pumkin

Feeding potential of *C. montrozieri*

The feeding potential of *C. montrozieri* against the sugarcane crown mealybug *P. saccharifolii* was confirmed by our laboratory studies. The first instar grub of *Cryptolaemus* were allowed to feed on first and second instar crown mealybug colonies infested sugarcane leaf whorls. The number of first and second instar crown mealybugs in the sugarcane leaf whorl was recorded prior to feeding. The food was changed every alternate days till pupation. Finally, the total number of mealybugs (first and second instar) consumed by a single *Cryptolaemus* grub was determined. The fast-feeding and highly mobile grub consumes up to 250 mealybugs during its lifetime. Thus, *C. montrozieri* serves as an effective predator for the biological control of mealybugs in sugarcane. Its use can reduce the reliance on chemical sprays and represents a valuable tool in integrated pest management and resistance management programs.

References

Siddhapara, M.R., Dumaniya S.G., and Kapadiya I.B. 2017. *Cryptolaemus montrouzieri* Mulsant – An important predator of mealybugs. Wheat Research Station, JAU, Junagadh, Gujarat - 362 001, India. 145-157pp.

Geetha, N., Viswanathan, R., Ramasubramanian, T., Salin, K.P., Yogambal, C., Nirmala Devi, P., Karthigeyan, S. and N. Chitra. 2022. *Phenacoccus saccharifolii* (Green) (Pseudococcidae: Hemiptera) on sugarcane in Tamil Nadu, India. Current Science, 10: 1142-1151.

AgriGate Editorial Team

December 2024 | Vol.No. 04| Issue 12


NamFarmers.com™
a Tara Blooms Initiative
Open gate for
AGRO PRODUCTS
Let's market globally
NamFarmers.com™
a Tara Blooms Initiative
English
Welcome Back, Kanakasabapathi
Good Afternoon!
Search Agri Jobs
Add Job Vacancy
Magazines
Rs. 160 / Kg(s)
Rs. 1800 / Litre(s)
Value Added Products
Moringa Leaf Powder
Tuticorin
Organic: Yes
Purpose: Selling
Quantity: 1 Kg(s)
Available Date: May, 26 2023
Value Added Products
Moringa Oil
Tuticorin
Organic: No
Purpose: Selling
Quantity: 1 Litre(s)
Available Date: May, 26 2023
GET IT ON
Google Play
Available on the
App Store
T&Cs Apply

AGRI INNOVA 2025

INTERNATIONAL CONFERENCE ON ADVANCED INNOVATIONS AND TECHNOLOGICAL FRONTIERS IN AGRICULTURAL SCIENCES, AGRICULTURAL ENGINEERING, SERICULTURE, FOOD TECHNOLOGY, BIOTECHNOLOGY, FISHERIES SCIENCE, VETERINARY AND ANIMAL SCIENCES 2025

Jointly Organized by

Western Ghat Researcher Association of Agricultural Sciences and Technology (Registered under Section 8 Organization, Ministry of Corporate Affairs, Govt. of India)

Department of Agricultural Engineering, RVS Technical Campus (Autonomous), Affiliated to Anna University Coimbatore, Tamil Nadu, India

Scan QR for Registration

Registration Extended to 30.12.2024

09th & 10th JANUARY 2025

VENUE: DEPARTMENT OF AGRICULTURAL ENGINEERING, RVS TECHNICAL CAMPUS (AUTONOMOUS), KUMARAN KOTTAM CAMPUS, KANNAMPALAYAM POST, SULUR, COIMBATORE, TAMIL NADU, INDIA.

In Coordination With

Academic Partner

RVS Agricultural College Affiliated to TNAU Thanjavur, Tamil Nadu

Technical Knowledge Partners

METVSO Research Foundation Madurai, Tamil Nadu

PROSPER Foundation Theni, Tamil Nad

Agri Amigos Pvt. Ltd., Theni, Tamil Nadu

Incubation Partner

Media Partner

Industry Knowledge Partners

CREA Foundation, Trichy, Tamil Nadu

Greenerg Mobility Solutions Pvt. Ltd., Coimbatore, Tamil Nadu

Department of Agricultural Engineering
RVS Technical Campus (Autonomous),
Affiliated to Anna University
Coimbatore, Tamil Nadu, India

Western Ghat Researcher Association of Agricultural Sciences and Technology
(Registered under Section 8 Organisation,
Ministry of Corporate Affairs, Govt. of India)

For Communication 9361885985 | 8610561280 | 9842642848 | 9944010268

PROSPER FOUNDATION
&
WESTERN GHAT RESEARCHER ASSOCIATION OF AGRICULTURAL SCIENCES AND TECHNOLOGY

PROUDLY PRESENT

TEACHING & RESEARCH EXCELLENCE AWARDS 2025

10th JANUARY 2025
VENUE: DEPARTMENT OF AGRICULTURAL ENGINEERING, RVS TECHNICAL CAMPUS (AUTONOMOUS), KUMARAN KOTTAM CAMPUS, KANNAMPALAYAM POST, SULUR, COIMBATORE, TAMIL NADU, INDIA.

REGISTRATION EXTENDED TO: 30.12.2024
FOR REGISTRATION: www.prospertheni.com

AGRI INNOVA 2025

Jointly Organized by

In Coordination With

Academic Partner | Technical Knowledge Partners | Incubation Partner | Media Partner | Industry Knowledge Partners

SUCCESS

Scan QR For Registration

PROSPER Foundation
(NGO Registration No. R/TN/4/105/2021)
Regd. in Govt of Tamil Nadu & Regd. in MSME, Govt. of India

Western Ghat Researcher Association of Agricultural Sciences and Technology
(Registered under Section 8 Organisation, Ministry of Corporate Affairs, Govt. of India)

For Communication 9361885985 8610266172 9842642848 8610561280

awards@agriinnova.in