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AgriGate

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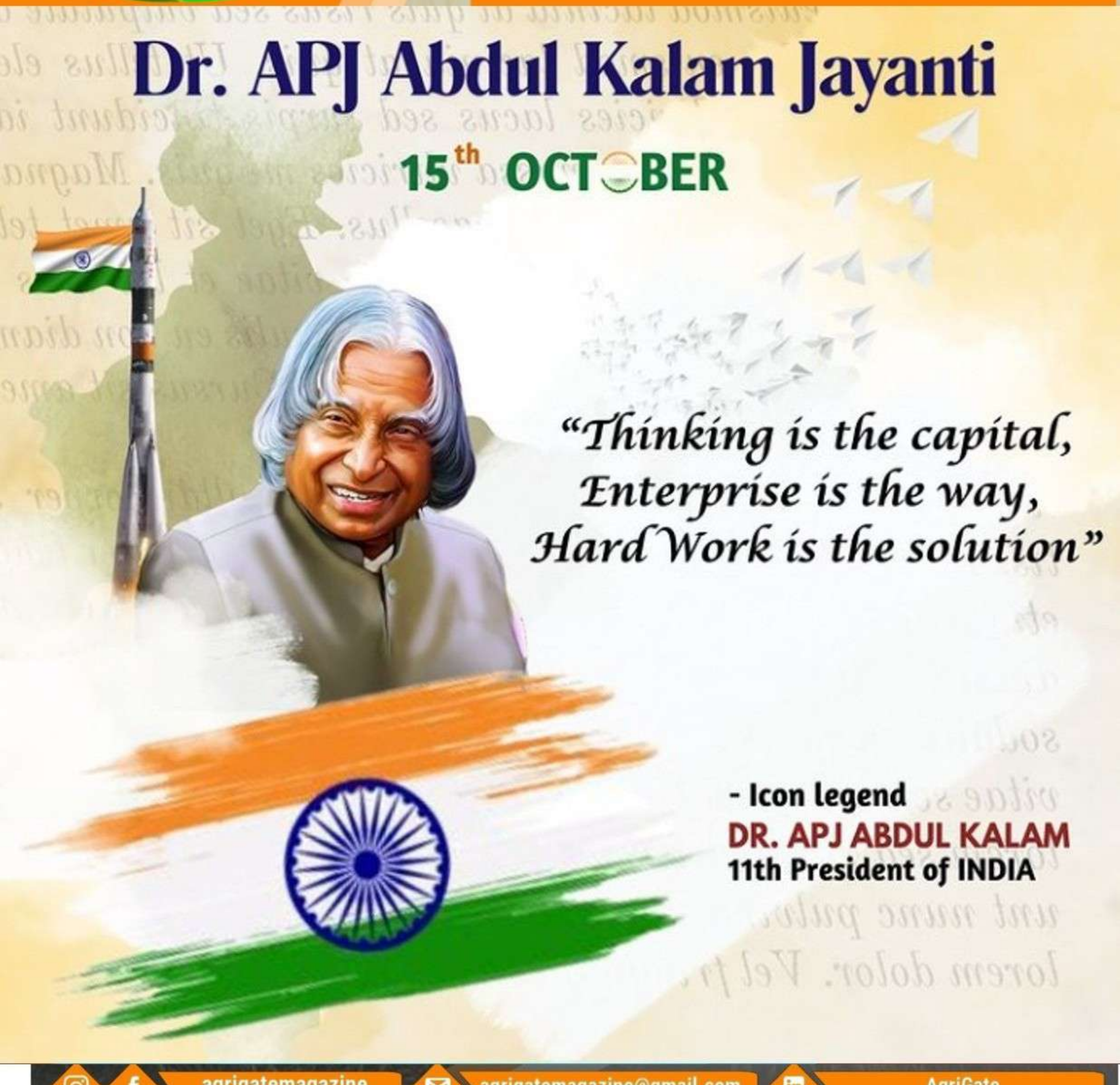
An International Multidisciplinary Monthly e-Magazine



From the Desk of Editor-in-chief

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I would like to introduce the launch of **"AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 04 Issue No. 10 – October 2024"** with immense pleasure. Our team is privileged to dedicate this issue to the **A.P.J. Abdul Kalam**. The birth anniversary of Dr. A.P.J. Abdul Kalam 2024, celebrated on October 15 as **World Student's Day**, honors the life of India's "Missile Man" Known for his work in science and as a former President, Dr. Kalam inspired millions with his dedication to education, technology, and serving the nation and also the role of the teacher that he played throughout his scientific and political careers.

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

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SOIL HEALTH AND ITS ROLE IN CROP PRODUCTION

Article ID: AG-VO4-I10-01

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Abstract

Soil health is critical for sustainable agriculture and crop production. As global food demand rises, maintaining healthy soils is essential for long-term agricultural productivity. Healthy soil is nutrient-rich, well-structured, and biologically active, supporting crop growth. However, unsustainable farming practices and environmental degradation have caused soil health to decline, threatening food security. This article examines the components of soil health, such as organic matter, microorganisms, and soil structure, and explores sustainable practices necessary to maintain and restore healthy soils for future agricultural productivity.

Keywords: Soil health, sustainable agriculture, crop production, organic matter, microorganisms and soil structure.

Introduction

Soil health is the cornerstone of sustainable agriculture and is directly linked to crop production. As the world's population grows and the demand for food increases, maintaining healthy soils has become more critical than ever. Healthy soil is rich in nutrients, well-structured, and biologically active, which supports robust crop growth and ensures long-term agricultural productivity. Unfortunately, unsustainable farming practices and environmental degradation have led to widespread soil health decline, jeopardizing food security. This article explores the components of soil health, their role in crop production, and the practices necessary to maintain and restore healthy soils.

1. Understanding the Components of Soil Health

Soil health encompasses physical, chemical, and biological properties that together determine its ability to support plant growth. Physically, healthy soil has good structure, meaning it is porous enough to allow roots to penetrate and water to infiltrate but also compact enough to retain moisture. Chemically, it contains essential nutrients like nitrogen (N), phosphorus (P), and potassium (K), and its pH is balanced to ensure nutrient availability. Biologically, soil health depends on the activity of microorganisms such as bacteria, fungi, and earthworms that decompose organic matter, recycle nutrients, and suppress plant diseases. When these components are balanced, they provide an optimal environment for crops to grow. For example, soil structure influences root development, water retention, and nutrient absorption. Soil health is dynamic and can change over time due to agricultural practices, climate conditions, and land use, making it crucial to manage these factors carefully for continued productivity.

2. The Role of Organic Matter in Enhancing Soil Fertility

Organic matter is a critical element in maintaining soil health and crop production. It includes decomposed plant residues, manure, and microorganisms, which together enrich the soil with nutrients. Organic matter improves soil structure by increasing its ability to hold water and nutrients, preventing them from leaching away. It acts as a reservoir of nitrogen, phosphorus, and potassium, releasing these nutrients slowly as organic matter decomposes. This slow release helps sustain crops over time, unlike synthetic fertilizers, which provide a rapid but short-term nutrient boost. Moreover, organic matter promotes soil aggregation, which helps protect the soil from erosion by wind and water. The binding properties of organic matter create stable soil aggregates that enhance water infiltration and reduce runoff, thus conserving water and preventing nutrient loss. Additionally, organic matter supports soil microorganisms, whose activity is essential for nutrient cycling and maintaining soil fertility. For farmers, increasing organic matter through composting, cover crops, or manure application is a sustainable way to enhance soil health and boost crop yields without relying heavily on chemical inputs.

3. Soil Microorganisms: The Hidden Heroes of Crop Growth

Soil microorganisms play a fundamental role in soil health and crop production, acting as nature's recyclers. They break down organic matter, making nutrients available for plant uptake, and improve soil structure. Bacteria and fungi are particularly important in nutrient cycling. For example, nitrogen-fixing bacteria such as Rhizobium convert atmospheric nitrogen into ammonia, a form that plants can readily use. Mycorrhizal fungi form symbiotic relationships with plant roots, helping them absorb more water and nutrients, particularly phosphorus, which is critical for energy transfer and root development in plants. In addition to nutrient cycling, microorganisms help protect crops from soil-borne diseases by outcompeting pathogenic organisms or producing substances that inhibit their growth. They also contribute to soil resilience, allowing crops to better withstand environmental stresses such as drought or flooding. Maintaining a diverse and active microbial community is essential for healthy soil. Practices like crop rotation, reduced tillage, and organic farming can foster soil biodiversity, whereas excessive use of chemical fertilizers and pesticides can harm beneficial microorganisms and disrupt soil health.

4. Soil Erosion: A Threat to Long-Term Agricultural Productivity

Soil erosion is the process by which the top layer of soil is removed by wind or water. This topsoil is rich in organic matter and nutrients, making it crucial for crop growth. When erosion occurs, it reduces the fertility of the soil, limits water retention, and makes the land less productive. In extreme cases, erosion can render agricultural land completely barren. Erosion is often exacerbated by conventional farming practices, such as intensive tillage, monoculture cropping, and leaving fields bare between growing seasons. Without plant cover, soil is exposed to the forces of erosion, especially in regions with heavy rainfall or strong winds. The loss of topsoil not only affects the current crop but also depletes the soil's long-term productivity. To combat soil erosion, farmers can adopt conservation practices like contour farming, which involves ploughing along the contours of a slope to slow water runoff. Planting cover crops during the off-season helps to protect the soil from erosion while also improving soil structure and fertility. Reduced tillage practices, which disturb the soil less frequently, also help maintain soil stability and prevent erosion.

5. The Importance of Soil Testing in Optimizing Crop Yield

Soil testing is an essential tool for understanding soil health and making informed decisions about crop management. A soil test provides critical information about nutrient levels, pH balance, and organic matter content, allowing farmers to tailor their fertilization and soil amendment strategies to meet the specific needs of their soil and crops. For instance, a soil test might reveal a nitrogen deficiency, prompting the farmer to apply the appropriate amount of nitrogen fertilizer. In addition to nutrients, soil testing can identify issues like soil salinity or imbalances in pH, both of which can affect crop performance. Most crops thrive in soils with a pH of 6 to 7; outside this range, nutrients may become unavailable to plants, or toxic elements may become more prevalent. By regularly testing soil, farmers can maintain optimal growing conditions, improve yields, and prevent overuse of fertilizers, which can lead to environmental issues like water contamination. In regions with intensive farming, soil testing helps monitor long-term soil health and ensures that agricultural practices do not deplete the soil's fertility over time.

6. The Impact of Soil pH on Nutrient Uptake and Crop Growth

Soil pH is a measure of the soil's acidity or alkalinity, and it has a profound impact on nutrient availability. Most essential nutrients are available to plants when soil pH is between 6.0 and 7.0. Outside this range, nutrient deficiencies or toxicities can occur. For example, in highly acidic soils (pH below 6), phosphorus becomes less available to plants, while aluminium can reach toxic levels, inhibiting root growth. In alkaline soils (pH above 7), micronutrients like iron and zinc may become less available, leading to nutrient deficiencies. Adjusting soil pH to the optimal range is key to maximizing crop yields. Farmers commonly use lime (calcium carbonate) to raise soil pH and sulphur to lower it. Regular soil testing helps monitor pH levels and ensures that corrective measures are taken when necessary. By maintaining the right pH, farmers can optimize nutrient uptake and improve plant health and productivity.

7. Water Infiltration and Retention: Key Factors in Healthy Soils

Water management is a critical aspect of soil health. Healthy soil allows water to infiltrate easily during rain or irrigation, preventing surface runoff and ensuring that water reaches plant roots. Soil with good structure, particularly soils rich in organic matter, can retain moisture longer, making it available to crops during dry periods. However, compacted or degraded soils often suffer from poor water infiltration and retention, leading to drought stress in plants or waterlogging those harms crop roots. Improving water infiltration and retention requires practices that enhance soil structure. For example, adding organic matter through compost or mulch improves soil porosity and water-holding capacity. Cover crops and reduced tillage also help protect soil structure, allowing it to absorb and retain more water. In areas prone to drought, these practices are essential for maintaining healthy crops and preventing water waste.

8. Soil Compaction: A Barrier to Root Growth and Crop Yield

Soil compaction occurs when the soil is compressed, reducing the pore spaces that allow air and water to move through the soil. This can severely restrict root growth, making it difficult for plants to access water and nutrients. Compaction also reduces the movement of oxygen into the soil, which can harm soil microorganisms and further degrade soil health. Heavy machinery, livestock, or even excessive foot traffic can cause soil compaction, especially in wet conditions when soil is more susceptible to compression. Compacted soil leads to reduced crop yields because plant roots cannot spread out or access the nutrients and water they need. To prevent compaction, farmers can adopt practices like reduced tillage, which minimizes soil disturbance, and controlled traffic farming, which restricts machinery to designated lanes in the field. In some cases, deep-rooted cover crops, like radishes, can help break up compacted soil layers and improve soil structure over time.

9. Sustainable Farming Practices for Maintaining Soil Health

Sustainable farming practices are essential for maintaining long-term soil health and ensuring continued crop production. These practices focus on preserving soil fertility, improving soil structure, and protecting the soil from erosion and degradation. Key sustainable practices include:

Crop Rotation: Alternating crops in a field to prevent nutrient depletion and break pest and disease cycles.

Cover Cropping: Growing non-harvest crops to protect the soil, improve fertility, and reduce erosion.

Reduced Tillage: Minimizing soil disturbance to preserve soil structure and microbial activity.

Organic Farming: Using natural fertilizers and pest control methods to enhance soil health and reduce environmental impacts.

By adopting these practices, farmers can improve soil resilience, reduce reliance on chemical inputs, and increase crop productivity in the long run.

10. The Future of Soil Health in Sustainable Agriculture

The future of sustainable agriculture depends on the health of the soil. As agricultural practices evolve, there is increasing focus on regenerative techniques that restore degraded soils and enhance their ability to support crops. Regenerative farming practices, such as agroforestry, holistic grazing, and no-till farming, aim to increase soil organic matter, improve water retention, and enhance biodiversity. These practices not only improve crop yields but also help mitigate climate change by sequestering carbon in the soil. Technological advancements, such as precision agriculture and soil monitoring tools, are also playing a crucial role in soil management. Precision farming uses data-driven techniques to optimize soil inputs, reduce waste, and monitor soil health in real-time. These innovations are helping farmers adopt more sustainable practices and ensure the long-term productivity of their soils.

Conclusion

Soil health is a fundamental aspect of agricultural productivity and sustainability. Healthy soils provide crops with the necessary nutrients, water, and support for growth while protecting them from environmental stresses. However, soil health is constantly under threat from unsustainable farming practices, erosion, and environmental degradation. By adopting sustainable farming techniques, improving organic matter, maintaining proper pH levels, and supporting soil microorganisms, farmers can enhance soil health and ensure long-term agricultural productivity. The future of farming depends on our ability to manage and restore the health of the soils that feed the world.

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MANAGEMENT STRATEGIES FOR PEST AND NON-INSECT PESTS OF GUAVA

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Introduction

More than 80 species of insects and mites have been recorded in guava trees affecting growth and yield. However in India, the major pests are polyphagous pest like tea mosquito bug, fruit flies, fruit borers, bark eating caterpillars mealy bug and introduced pest namely spiraling white fly.

Tea moquito bug / Guava kajji bug : *Helopeltis antonii* (Miridae : Hemiptera)

Identification of pest

- **Adult** is slightly bigger than mosquito and reddish brown in colour with long legs and antennae.
- Black coloured head and red coloured thorax. A white band is seen on the lower surface of the abdomen.
- A peg like projection on the dorsal side of the scutellum, A peg like projection .It is distributed in South India, Srilanka, South- east Asia .

- It is a major pest of guava and widely distributed in Karnataka, Goa, MH, and TN Alternate hosts : Cashew, Tea, Cocoa, Rose, Tamarind, Apple.
- **Eggs**: Female can lay 500 eggs that are insert into the epidermis of tender shoots, axis of inflorescence, the flower buds, tissues of twigs, midribs of leaves and where scars may be seen I.P – 6-7 days .
- **Nymphs** : There are five nymphal instar The nymphs are small, reddish brown ant like and second instars they develops the horn on the scutellum. N.P – 14-16 days.
- **Adult:** bug The life cycle is completed in 22 days .The adults and nymphs suck the sap from tender shoots and fruit of all sizes .

Symptoms:

- When they suck the sap from fruits, the pierced area develops in to a raised corky scab or kajji appearance .
- They suck the sap from tender fruit the spots may coalesce and finally develops into a blisters or scab like areas on the fruit surface, such fruit are inferior in quality and become unmarketable. Nymphs and adults make punctures on petiole, tender shoots and fruits .
- Elongate streaks and patches develop on shoots . The affected leaves and shoots are dry up .
- A blisters or corky scab formation on the fruit surface.

Critical stages of pest attack:

- New flush formation stage . Production of new fruits.
- If not taken care in these stages fruits will drop off .

Management practices

- To prune the branches or to regulate the shade to facilitate proper penetration of sunlight inside the canopy.
- When new flush arises spray the crop with contact insecticides like Monocrotophos 36 WSC @ 2.5 lit. in 1500 – 2000 lit. water per ha .
- Spray malathion @ 2 lit in 1500 – 2000 lit. water per ha + Urea 3% at flower initiation and again at fruiting time.

Spiraling white fly : *Aleurodicus dispersus* (Aleyrodidae : Hemiptera)

Identification of pest

- **Adults** are larger in size, body yellowish hyaline with white waxy powder on the body.

- It is an introduced polyphagous pest of vegetables, fruit trees, ornamentals and shade trees.
- **Eggs**: are laid in a spiraling pattern (concentric circles) on the undersurface of leaves. Egg period lasts for 5-8 days.
- **Nymphs** : Nymphal period is 22-30 days. Adult longevity is for 13-21 days. Total life cycle is completed in 40-50 days.

Nature of damage

- Both nymphs and adults suck the sap on the lower surface of the leaves in colonies.
- This leads to chlorosis and early senescence of leaves (become old), Honey dew supports the sooty mould fungus.
- As a result the vigour and vitality of the plant reduced and photosynthetic activity also affected.

Integrated Pest Management

- Remove and destroy damaged leaves along with life stages.
- Remove and destroy weed plants like Abutilon, Acalypha, Euphorbia, etc., in the nearby vicinity as these plants are alternate hosts.
- Use yellow sticky traps at 15 / ha to attract and kill the adults.
- Release Chrysoperla zastrowii predators at 10000/ha to kill all life stages .
- Encourage the activity of predators such as Coccinellids, Chilocorus nigritus, Cheilomenus sexmaculatus, etc.
- Conserve spiraling whitefly parasitoids, Encarsia haitiensis and E. guadeloupae.
- Spray Fish oil rosin soap (FORS) @ 25g/lit. or NSKE @ 5% or neem oil 0.03% i.e. 1ml / lit or phosalone 35 EC @ 3 lit. or triazophos 40 EC @ 3 lit. or acephate 75 SP @ 1.5 kg in 1500 - 2000 lit. per ha. And spray two to three times based on the incidence.
- Avoid using synthetic pyrethroids and extending crop growth.

Scale insects

- *Chloropulvinaria psidii* (Coccidae : Hemiptera)
- It is a major pest of Guava in Karnataka, Tamil Nadu. AP, MH, UP and Punjab Alternate hosts : Apart from Guava, the scale insects feeds on Coffee, Tea, Citrus, Mango, Jack fruit, Sapota etc.,

Identification of pest

- **Adults** are ovoid, green to yellow in colour, and covered with a white powdery wax. The eyes are black in colour.
- Adult females and nymphs green to yellowish in colour broadly oval shaped and flat and measures 3mm in body length .
- Males are small with one pair of wings and harm less First instar nymphs are crawlers are the active dispersive phase responsible for starting new infestation.
- **Eggs**: are laid beneath the body of mature female in a prominent ovisac / egg sac later female dies.

Nature of damage

- Nymphs after hatching feed on leaves and shoots, the attack of these insects are more common in summer .

Management practices

- Prune the affected parts and burn at the early stage of infestation during non fruiting stage.
- In case of severe infestation, prune the affected parts and spray during non fruiting or early fruiting season with monocrotophos @ 2 ml / lit. or quinalphos @ 2ml / lit.
- After two weeks, release 20 adults beetles of *Cryptlaemus montouzieri* / plant in the month Jan or Feb. This beetle prefer to feed on the ovisac of the scale insect than other stages.
- A total 400 eggs can be consumed by a single beetle grub during the development (10 grubs / tree) other natural enemies – *Chrysoperla zastrowii*, *Spalgis epius* Parasitoid – *Aenasius advena* .
- Sticky substance or Alkathene bands to the base of the plant to prevent movement of ants and pest .

Mealy bugs : *Ferrisia virgata* (Pseudococcidae : Hemiptera)

Nature of damage

- These are persistent pests. They suck the sap from twigs and leaves, some times they thickly infests on these parts including fruits.
- As a result curling and twisting of twigs and in poor developed . Infested fruits will have uneven shapes, poor quality, and are susceptible to secondary infections by pathogens.

Identification of pest

- Bugs are small reddish, the posterior part covered with white cottony material which serves as ovisac for egg and young ones .

Favourable condition

- The maximum temperature had significant positive correlation with the build-up of population of mealy bugs while high humidity had significant negative correlation.
- The other meteorological parameters, i.e. minimum temperature, relative morning humidity and rain, had no significant influence on the incidence of the pests.
- A major pest of several vegetables, ornamental plants, tropical orchard trees and was observed feeding on 76 species of plants belonging to 33 families.

Management practices

- Debark the vines and swab with methylparathion @ 1 ml / lit. to minimize the population.
- Spray dichlorvas 1.0 lit. or chlorpyriphos 1.25 lit. or buprofezin 25 SC 1.0-1.5 lit. in 500 lit. water/ha .
- Spray the crop with neem oil upto 4 % or Honge oil 400ml + 50ml of liquid soap in 10lit. of .
- Release Australian lady bird beetle, *Cryptoleamus montrouzieri* @ 2500 – 3750 per ha .
- Conserve coccinellid beetle, *Scymnus coccivora* and lepidopteran predator *Spalgis epius* ,*Encarsia advena* – 50 % parasitisation takes place in natural condition.
- Avoid spraying methyl parathion, monocrotophos, dimethoate, methyldemeton, quinalphos, malathion etc., as they are toxic to predators.

Mango mealy bug : *Drosicha mangiferae* (Margarodidae : Hemiptera)

Incidence of mango mealy bug, *Drosicha mangiferae* has been noticed in winter season crop.

Symptoms

- Excessive de-sapping results in yellowing, withering, drying and shedding of leaves, drying young shoots and dropping of affected fruits.
- Secondary infection of sooty mould takes place on honey dew, excreted by these insects, hindering the photosynthetic activity of the plant .
- The nymphs suck the sap from leaves, shoots and fruits.
- Development of sooty mould takes place on the honey dew excreted by these insects on the affected parts.

- The infested fruits drop prematurely and mature fruits loose their market value Infestation of mango mealy bug on fruits .

Management practices

- The affected leaves and young shoots may be pruned and destroyed alonging with the pest in early fruiting or non fruiting season.
- It helps in brining down the initial pest population and prevent further spread .
- Overlapping and overcrowding branches may also be pruned to check spread of these pests in the orchards.
- In case of heavy infestation of *F. virgata* .Spray the crop with 0.1 % buprofezin or 0.045% dimethoate in early fruiting or non fruiting season . may be repeated at fortnightly intervals depending on the severity of attack .
- For prevention and control of mango mealy bug (D. mangiferae) alkathane banding (400 gauge 25 cm wide) may be tied with the help of thread on tree trunk .
- In case of heavy infestation – 1.5 % chlorpyriphos dust @ 250gm / tree may be applied by raking the soil around the tree trunk .This may be done particularly when guava orchards are located in the vicinity of mango orchards .
- Releasing of *Cryptolaemus montrouzieri* @ 3000 / ha before fruiting seasons.

Fruit fly: *Bactrocera dorsalis* (Tephritidae : Diptera)

Identification of pest

- Adults are brown or dark brown coloured flies with hyaline or transparent wings and yellow coloured legs.
- A little bigger than the house fly.
- It is the common one frequently effects the guava orchards all over the Country they become active during spring season.
- The fly population dwindles (less) in summer and raises during the rainy months March – June and September –November.
- **Egg**: Under optimum conditions, a female can lay more than 3,000 eggs during her lifetime, but under field conditions from 1,200 to 1,500 eggs per female is considered to be the usual production. Development from egg to adult under summer conditions requires about 16 days.

- **Larva**: The mature larva emerges from the fruit, drops to the ground, and forms a tan to dark brown puparium.
- **Pupa**: Pupation occurs in the soil. About nine days are required for attainment of sexual maturity after the adult fly emerges.
- When ever crop having semi ripe fruits to over maturity fruits, the females they lay eggs on the fruits i.e. ovipositional punctures on the fruits .
- Maggots feed on inner content/ pulp of the fruit and convert the pulp in to bad . Finally the maggot fall down to the ground and under go pupation inside the soil

Nature of damage: Maggots feed on inner content of the fruit

- Ovipositional damage in the form of minute depression may be seen from out side .
- Fruits are soften at site of infestation The affected fruits rot and drop pre-maturely.
- Ovipositional aperture leads to secondary infection by several pathogens .

Management practices

- To maintain sanitation in Orchard including removal of fallen fruits regularly .
- Use methyl eugenol traps to keep fruit fly population under check (see under mango).
- Summer ploughing to expose pupa and hibernating larvae are destroyed by natural enemies.
- Bait spray combing molasses or jaggery @ 10 gm / lit. and one of the insecticides fenthion 100EC @ 1 ml / lit. dimethoate 30 EC @ 1 ml / lit. malathion 50 Ec @ 2 ml / lit. Two rounds at fortnight intervals before ripening of fruits .
- Fruit flies with ovipositional damage Fruit flies attracted to drop of methyl eugenol .

Anar butterfly: *Deudorix (= Virachola)isocrates* (Lycaenidae : Lepidoptera)

Identification of pest

- **Adult** – bluish brown butterfly, Female – V shaped patch on the forewing.
- **Eggs**: Eggs are laid singly on calyx of flowers and fruits , stalks and flower buds.
- **Larvae** – Dark brown, short and stout, covered with short hairs, larval period lasts for 18-47 days.
- **Pupa**: Development occurs either inside the damaged fruits or on the stalk of the fruit Pupal period lasts for 7-34 days. Total life cycle is completed in 1 to 2 months.

Nature of damage

- Caterpillar / larva bores into young fruits.

- Feeds on internal contents (pulp and seeds) making the fruit hollow from inside.
- Fruit rotting and dropping . Infestation of this pest results in fruit loss .
- The entry and exit holes of the larvae are the way for secondary infection by different .
- Fruits damaged by *D. Isocrates* Larvae inside the damaged fruits.

Castor capsule borer : *Conogethes puntiferalis* (Pyralidae : Lepidoptera)

- This borer is the another polyphagous insect, larvae of which damage fruits of guava .
- It is a primarily a pest of castor but also attacks guava and other fruits and forest trees and occasionally cause serious damage .

Identification of pests

- **Egg**: Pink colored eggs laid singly on flower buds, or young capsules.
- **Larva**: Pale reddish brown in colour with black blotches and tubercles on body.
- **Pupa** : Pupates on plants in stem or capsule.
- **Adult:** yellow moth with black coloured dots on wings.

Nature of damage

- Stem dries up as larva bores in to stem and then damages the young fruits .
- Caterpillar bores into young fruits but they may also bore buds and tender shoots.
- Feeds on internal contents. Infected fruits dry up and fall off without ripening.
- The affected fruits are generally deformed at the point of entry of larvae.
- Larval faeces may be seen out of the borer hole. Such fruits weaken, rot and drop down.

Control measures

- Cultivation of pomegranate should be discouraged close to guava is most preferred host .
- Regular collection of infested fruits and their destruction to check the further spread and carry over the population .
- To prevent the infestation of pest, spray the crop with ethophenoprox @ 0.05 % at the beginning of fruiting season and before ripening of fruits .
- At least 15 days waiting period should be observed before beginning of harvest . Fruits damaged by *Conogethes punctiferalis*

Barking eating caterpillar : *Indarbela tetraonis* (Metarbelidae : Lepidoptera)

- Adult is stout yellowish brown coloured moth with grey wavy markings on the wings .
- Males are smaller than the female .

- Alternate hosts : the bark eating caterpillars feeds on Citrus, Mango, Guava, Mulberry, Pomegranate, Drumstick etc.,

Nature of damage

- The infestation of this pest may be identified by the presence of irregular tunnels and patches covered with silken web consisting of excreta and chewed up wood particles on the shoots, branches, stem and main trunk.
- Shelter holes may also be seen particularly at the joints of shoots and branches.
- The young shoots dry and die away giving sickly look to the plant .
- Damage of bark eating caterpillar on trunk Infestation of bark eating caterpillar on twigs.

Management practices

- Keep the orchard clean and healthy to prevent the infestation of this pest .
- Remove alternate hosts, silk cotton and other hosts. Detect early infestation by periodically looking out drying young shoots.
- Swab coal tar + kerosene @ 1 : 2 on the basal portion of the trunk up to 3 feet height.
- Scraping the loose bark to prevent ovipostion by adult beetle .
- If infestations are severe then apply the copper oxychloride paste on the trunk of the tree.
- Apply carbofuran 3G 5 gm / hole and plug with mud or Apply monocrotophaos @ 10 to 20 ml / hole .

Non insect pest

Scarlet Mite: *Brevipalpus phoenicus* (Tenuipalpidae: Acari).

- Mite lays eggs on stalks of fruits, calyx and leaves.
- Both nymphs and adults suck the cell sap from fruits which results in browning of nodal regions and appearance of brown patches on calyx and surface of fruits.
- In severe infestation, these symptoms cover the entire surface of fruits leading to splitting of fruits.
- **Life cycle** completed in 22 days.
- **Management practices:** Collect and destroy the damaged plant parts. Spray wettable sulphur 3 kg or dicofol 2 lit. in 1500 – 2000 lit. of water per ha.

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NERIUM – AN IDEAL HIGHWAY SHRUB

Article ID: AG-VO4-I10-03

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Introduction

Neriums are summer flowering, perennial ornamental crops belongs to the family Apocyanaceae. They are mostly found distributed in the dry tropical regions of India. The three commercially important species of Nerium are *Nerium indicum, Nerium oleander* and *Nerium oleander* var. *variegata*. They are commonly known as Kaner or Oleander. The Nerium cultivars are named after their form and colours of the flowers. Some of the varieties of Nerium include Single Rose, Single White, Single Red, Double Rose, Double White, Double Red, Double Rose, Pink, White, Yellow etc. and Dwarf types like Petite Salmon, Petite Pink etc.,

Nerium planting in highways

It is commonly known as ‘Arali’ in Tamil, ‘Kaneer’ in Hindi, ‘Raktakarabi’ in Bengali, ‘Kabirei’ in Manipuri and ‘Kananpar’ in Mizo. This crop thrives in tropical and subtropical climates and bears blossoms constantly throughout the year. It is one of the well-known sclerophyllous plant that can able to endure the extended durations of heat and dryness. It can withstand both drought and flooding, but cannot resist the protracted period of frost. Nerium bears flowers round the year in clusters of five lobed flowers. Because of its beautiful and profuse flowering habit and good shelf life period, nerium is commercially grown under South Indian conditions. The flowers are used for garland making as its spiritually valued for worshipping in temples. In India, commercial cultivation of nerium is confined to Tamil Nadu with an area of 2,303 ha contributing 5.3% in total flower cultivation (Anonymous, 2023). Owing to its continuous demand especially during the festive seasons, the area of cultivation is increasing due its versatile adoptability, less labour and low input requirement for commercial cultivations.

Botany

It grows up to 4 m in height. The leaves are linear-lanceolate in shape. Flowers are white, pink or red in colour. Flowers have a pleasant smell and are 4-5 cm in diameter. Fruits are cylindrical in shape and grow in pairs. Seeds are numerous, white in colour with smooth hairs.

Features

Nerium is a wonderful easy-care, rounded shrub or small tree, with long, dark green leaves and an abundance of single or double, sometimes fragrant flowers in shades of white, pink, red, or yellow. Often trained into an attractive small tree, multibranched Oleander also does well as a quick-growing screen or large specimen planting. Nerium is one of the easiest shrubs to care for. Sometimes suckers produced at the base of the plant will siphon off too much energy and flowering will be inhibited. These suckers should be pulled to remove them when they are young and succulent. The plant can be trained into a short central leader in the nursery and is often sold as a "standard" Oleander. It grows into a round-headed ball, flowering year-round.

Nerium survives drought well and is well-suited to growing on soil too poor for most other shrubs, even tolerating salt spray, brackish water, and alkaline soil. It thrives in full sun, appearing too lanky and flowering little if planted in partial shade. It is commonly planted in highway medians as a no-maintenance plant. It grows following wet weather, slowing down in drought, but always looks good even in powder dry soil.

Single type

Double type

Garland	Bridal veni
	

Landscape uses

Nerium is a versatile landscape plant for sunny seaside and inland locations. It is one of the basic shrubs used for hot, dry locations. Oleander has fast growth, showy flowers and is adapted to full sun and poor soil conditions. It has high tolerance of drought and soil salinity. Selection and hybridization have resulted in cultivars of various sizes, flower colors, and shapes. Oleander is popular for screens but can also be used as a small “standard” tree or shrub or as a potted plant. Dwarf forms can be used as a large groundcover, landscape shrub, or container plant. For best results and minimum maintenance, choose a cultivar with growth characteristics and ultimate size that fits the intended landscape use. Full sun is necessary for best flowering and development of a full, fountain-shaped crown. In shade, growth becomes lanky, and plants produce few flowers. Oleander tolerates a wide range of soil types and grows well in sandy, dry soils. It is adaptable to a soil pH range of 5 to more than 8.

Propagation and planting

Neriums are propagated by Hardwood or semi hard woodcuttings of 60 cm length. The cut ends are buried inside the soil forming an arch. Rooted cuttings are planted during the months of June to July in 30 cm x 30 cm x 30 cm pits filled with FYM, red earth and top soil. Neriums are usually planted at a spacing of 2 m x 2 m.

Soil and Climate

It performs well under tropical and subtropical conditions. Red lateritic or black or loamy soils with adequate provision for drainage are suitable for commercial cultivation.

Pruning

Pruning is an important intercultural operation in Nerium. Pruning is done by heading back the vigorous past growth. All the weak, diseased, criss cross and unproductive shoots are to be removed. The cut end should be protected with Bordeaux paste or copper oxy chloride paste to prevent die back. 1st year - Remove one third of the old mature stems near ground level. 2nd year - Remove one half of the remaining old stems and cut back long new shoots. 3rd year - Remove remaining old stems and cut back long new shoots.

Biofertilizers

Soil application of 2 kg each of *Azospirillum* and Phosphobacteria per ha at the time of planting. It is to be mixed with 100kg of FYM and applied in pits.

Irrigation

The plants are irrigated once in 10 - 15 days depending on the weather conditions.

Plant protection

Pests and diseases

No serious pests or diseases are found to affect this crop.

Leaf Caterpillar

The Oleander caterpillar can defoliate a plant within a week. Spray Quinalphos 25 EC 1 ml/lit or Phosalone 35 EC 1 ml/lit to control the pests.

Flowering season

Nerium flowers throughout the year. Peak flowering season is between April to August.

Harvesting and Yield

Harvesting of flowers can be done from fourth month after planting. The fully developed and open flower buds are harvested. Harvesting time is early morning and late evening. An approximate yield of 100 - 125 kg of flowers/ha/day can be obtained.

Uses

The flowers of Neriums are used as both cut flowers and loose flowers. They are widely used in garlands, veni and as offerings to God. The plants are used in landscaping and for avenue planting.

Toxicity

All parts of the plant are poisonous so care must be taken when locating Oleander near areas frequented by small children; burning of the trimmings will produce toxic fumes. Even chewing once or twice on a leaf or twig can send a person to the hospital.

Production constraints

Although the area and demand is markedly increasing, the main problem associated with cultivation is harvesting of flower buds. With the use of a headlight, the growers harvest the mature flower buds from late night to early in the morning hours as the flowers exhibit full bloom in the morning. During the phase of harvesting, farmers face snake, scorpion and reptile bites causing ill effects to the farming fraternity.

Ideal crop for Highway planting

Nerium plants, commonly known as oleanders, are often planted along highways for several reasons:

1. **Landscaping and Aesthetics:** Neriums are colorful flowering plants that can add visual appeal and enhance the aesthetic of roadside landscapes. Their vibrant blooms in shades of pink, white, and red can create an attractive and welcoming environment for drivers and passengers.
2. **Soil Stabilization**: They have extensive root systems that help stabilize soil and prevent erosion along highway embankments and medians. This can be particularly important in areas prone to soil erosion or landslides, helping to maintain the structural integrity of the roadway.
3. **Drought Tolerance**: Oleanders are highly drought-tolerant plants that can thrive in areas with limited water availability, making them a practical choice for roadside plantings in dry or arid climates. This drought resistance reduces the need for intensive watering and maintenance.
4. **Low Maintenance**: Neriums are relatively low-maintenance plants that require minimal care, such as occasional pruning or trimming. This makes them a cost-effective option for highway landscaping, as they require fewer resources and labor inputs compared to more high-maintenance plant species.
5. **Pollution Tolerance**: They are known to be tolerant of air pollution, salt, and other environmental stressors commonly found along highways. This makes them a suitable choice for thriving in the challenging conditions often encountered in roadside environments.
6. **Shrub** : Is not that magnificent enough to cover the path and the opposite lane, but is sufficiently green. These trees don't have hard wood, so even if a vehicle at high speed gets off track and collides with these, the impact would not be that serious

7. **Woodless** : Generally, in India, past projects of green drives along canals and roads have failed due to involvement of wood mafia and anti-social elements who cut down the wooded trees. This shrub is woodless and hence, no such danger.
8. **Toxic to cattles**: In Indian context, cattles play a role in destroying road-side plantation by grazing on it and thereby causing road blockage. But they are averse to this plant, eliminating all these issues. Nerium plants are not eaten by animals so they don't attract animals on highways.

Overall, the combination of their aesthetic appeal, soil stabilization properties, drought tolerance, low maintenance requirements, and pollution resistance makes oleanders a popular choice for highway plantings in many regions.

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FRUIT FLIES: AN INCESSANT PEST IN GUAVA

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Introduction

Guava (*Psidium guajava* Linn.) is an important fruit crop from the Myrtaceae family and is often referred to as the "Poor man's apple" or the "Apple of the tropics." Native to Central America, it was brought to India by the Portuguese in the 17th century. Its ease of cultivation, high nutritional value, and popularity in processed products have made it a significant crop in international trade and in the economies of over 50 tropical countries. Guava is abundant in protein, vitamin C, ascorbic acid, and calcium. Guava is not only rich in iron and phosphorus but is also commonly used both as a fresh fruit and in the preservation industry for making products like jam and jelly. Guavas are known for their high ascorbic acid (vitamin C) content, though the levels can vary significantly, ranging from 10 to 2,000 mg per 100 grams of fruit, depending on the cultivar, environmental conditions, and tree management practices. The highest concentrations of ascorbic acid are found in the stem and outer flesh of the fruit.

Potential and nature of damage of fruit flies

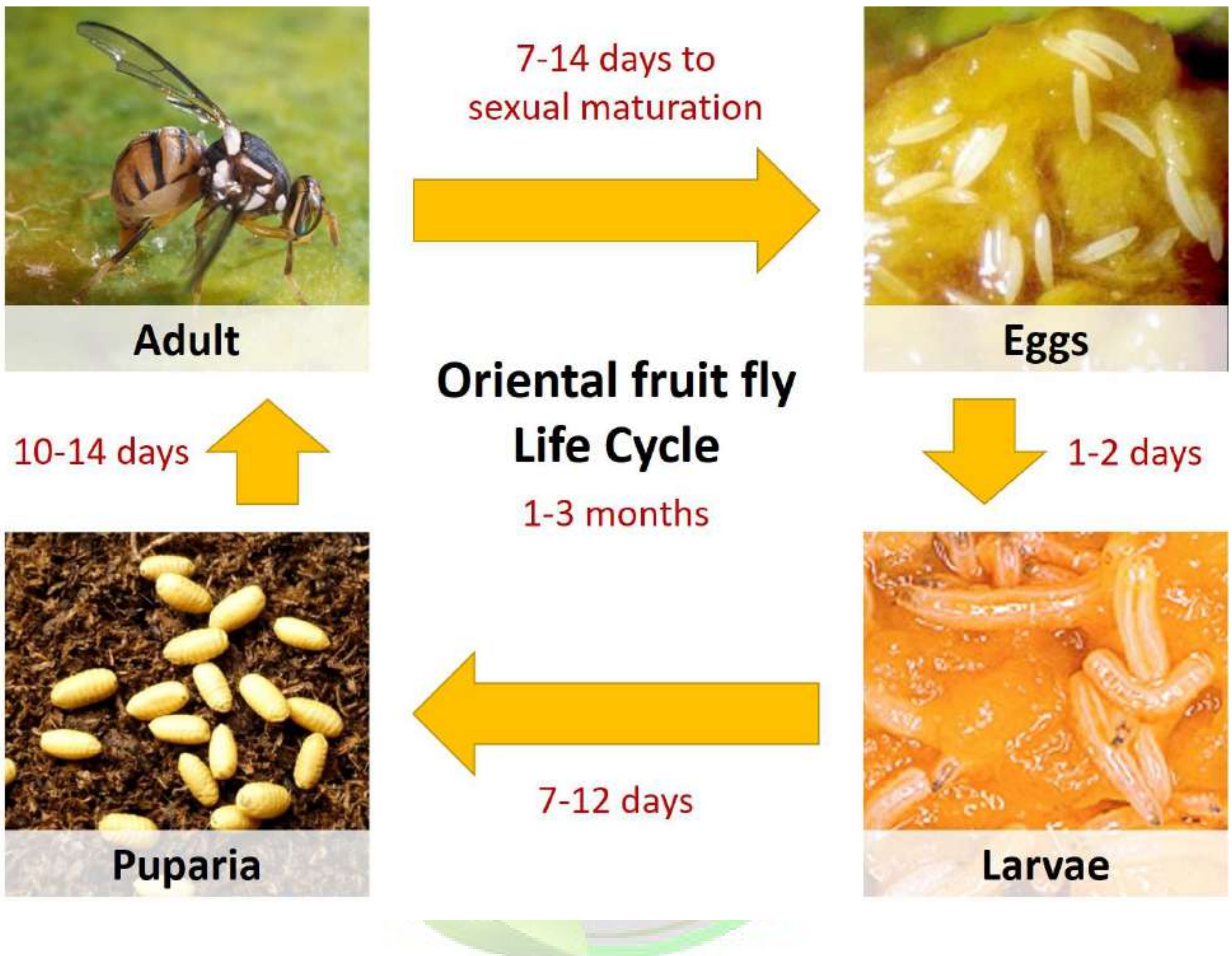
Guava orchards worldwide are infested by almost 800 different types of insect pests, such as fruit flies, caterpillars that eat bark, and capsule moths. The infestation of fruit fly is a major limiting factor in the production of guava. Depending on the population, location, variety, and season, the crop loss can range from a few to 100 percent (Sharma *et al.* 2015). Fruit flies are tiny insects from the Dipteran order, are notorious for damaging soft-bodied fruits and vegetables, with potential losses ranging from 20 to 100 percent. In India, these pests significantly affect various fruit crops, with guava being particularly vulnerable. Fruit fly infestation can cause considerable damage to guava, leading to yield reductions and quality issues. In Uttar Pradesh, the infestation rate varies from 20 to 46 percent, resulting in losses of 16 to 40 percent, particularly during the rainy season. The guava crop faces threats from nearly 80 species of insect and mite pests, though only a few are considered serious pests. Among these, fruit flies (*Bactrocera* spp.) are particularly damaging, responsible for 60 to 80% of the fruit damage (Jalaluddin *et al.*, 1999). Fruit flies are polyphagous and can travel up to two kilometers in search of food (Butani, 1974). Key fruit fly species affecting guava in India include *Bactrocera dorsalis, B. zonata, B. correcta, B. caryea, and Zeugodacus tau*, with males attracted to methyl eugenol and Cue lure for trapping.

Guava is most favourable crop for completing growth stages (egg, larvae, pupa, and adult) of fruit flies (Singh and Sharma, 2013). The maggots that hatch from these eggs feed on the fruit, and they prefer the turning green stage of the fruit, accelerating decay and rendering it unfit for consumption. Severely infested fruits often fall to the ground before the maggots pupate. In addition to direct damage, fruit flies also have an indirect economic impact by affecting fruit exports and causing substantial economic losses (Heather and Hallman, 2008). Due to these issues, India is one of the countries where fruit imports are restricted by developed nations (Stone House *et al.*, 2002). Adult fruit flies lay eggs in ripening or soft fruits, leading to blemishes, discoloration, and eventual rotting due to maggot infestation and secondary infections.

Climate and Ecology

In India three *Bactrocera* spp. mostly damage the guava crop (Kapoor, 2002). Fruit fly grows best in warm and humid climate. Best temperature for *B. zonata*, *B. dorsalis, B. correcta* is 22-30°C, approximate 20 egg punctures per fruit, it takes 8 days for maggots to come out of fruit, whereas there are 48 maggots and larvae per fruit, pupal duration is 8 days, number of adult emerged per fruit is 44 and sex ratio 1:1.15in *B. zonata* (M: F), 1:1.30 in B. dorsalis and 1:1 in *B. correcta*. A positive correlation between fruit fly catches and maximum and minimum temperatures, as well as morning and evening relative humidity, but no correlation with rainfall and a negative correlation with wind velocity. The pheromone lures were effective for up to 30 days.

The notable population peaks of *B. dorsalis* in March-April, May-June, and September-October, with peak activity aligning with the ripening of guava and mango fruits. Trap catches were significantly influenced by maximum and minimum temperatures, mean temperature, and maximum relative humidity(Shukla and Prasad, 1985).



Species of fruit flies recorded in Guava

1. *B. dorsalis*
2. *B. zonata*
3. *B. Correcta*
4. *B. tau*
5. *B. cucubitae*
6. *B. tuberculata*
7. *B. scutellaris*
8. *B. diversa*

Fruit flies damage in guava

Integrated Pest Management

Organic insecticides

Use of organic insecticides is an environment friendly method to control fruit fly, which are prepared from plants as tea plant (Melaleuca bracteata) and basil (Ocimum spp) via distillation of leaves and extraction of methyl eugenol (attractant for fruit fly).

By placing methyl eugenol ($C_{12} H_{24} O_2$) in trap, fruit flies get trapped. Fruit flies of guava orchard consume methyl eugenol before matting, which are acts as sex pheromone

Bait Application Technique

Female fruit flies are important for multiplication of the pest. They need protein source to mature sexually and for the development of their eggs which leads to female targeted system normally consists of traps baited with a liquid solution prepared by protein and fermenting sugar Female fruit flies attract significantly to different protein food baits containing proteinex and 5 per cent ammonium acetate

Male Annihilation Technique (MAT)/Eradication Eradication

Several male attractants such as methyl eugenol, cuelure, ceralure, terpinyl acetate, trimedlure, EGOlure, can be used with an appropriate toxicant. The bait placed area will attract and kill male fruit flies before they can breed. The attractant is very specific for this group of flies, other insects such as butterflies or bees will not be harmed because they are not attracted to the lure. Trapping has been found useful for both monitoring and management.

Different traps viz., IIHR bottle trap, Steiner trap, McPhail trap, delta trap, Jackson sticky trap and open pan trap are in practice now a days. The most efficient traps for fruit flies monitoring are IIHR bottle trap and plastic McPhail-type trap baited with torula yeast lures.

Wrapping of fruits

Wrapping of bagging is a superior option of fruit fly management over conventional practice of pesticide spray for its efficacy and zero pesticide residues in the fruit. Guava fruits, bagged with biodegradable poly-films before 6-9 weeks of harvesting which effectively controlled fruit fly. Bagging not only keeps the female flies away from the fruits but also improves the texture, color and quality of the fruits. Wrapping can be done with materials like polypropylene, plain paper or newly developed non-woven poly fabric

Controlling Fruit Fly – Bagging of Fruit

INSTALLATION OF FRUIT FLY TRAP

Biological control

Entomopathogenic nematodes can be very effective against life stages in the soil. Ploughing or raking of soil and treatment with *Metarrhizium anisopliae* @ 5 kg/ha to the soil underneath the tree canopy reduces fruit flies (Firake et al., 2013).

Few parasites and predators are observed to suppress fruit fly Bactrocera spp., *Diachasmimorpha longicaudata (Biosteres longicaudatus)* and *Diachasmimorpha tryoni* for Bactrocera dorsal is was useful The egg parasitoid, *Biosteres arisanus* (Sonan) is dominant parasitoid emerging from harvested guavas. *D. longicaudata* increased in abundance and parasitism rates on the ground after 6-10 days.

The eulophid parasitoid, *Tetrastichus giffardianus* (Silvestri) is more abundant in 4-9days old ground fruit (Purcell *et al.*, 1994).

Cultural practices

Prevention is the best method to control of fruit flies. Deep ploughing of soil, land drainage, planting of resistant rootstock, destroy of fallen fruits by burning them in the ground, adopting clean cultivation of orchard, proper plant spacing, pre mature harvest of fruit and avoid flood and channel irrigation are some important practices followed for management of fruit flies

Chemical control

Chemical control is the last resort due to its residual effect. Chemical control also can be applied with integrated pest management. Pre harvest spray using either dimethoate 0.06%, carbaryl 0.2% or deltamethrin 0.0028% are recommended for control of flies. Safer waiting periods are to be given each chemical pesticide used.

For guava orchard, poison bait for fruit flies and moths is Gur + fruit juice 20% + Malathion 2% @ 40 baits/ha (Firake et al., 2013).

Hoeing under the tree canopy at 15 days interval along with collection of fallen fruits and burying deep in the soil and spray of Spinosad is most effective to reduce the fruit fly infestation 6% followed by hoeing and sanitation along with the spray Diptrex 80% WP @ 150 gm / 100 liters of water (Khan et al., 2017).

Conclusion

Fruit flies are serious pest for guava globally in guava cultivating countries , proper quarantine inplaceis th nedd of the hour for controlling the pest and having pest free area of guava orchards are very essential like in mangobe. In India possibility to focus on genetic makeup of flies through RNA interface for their control, while integrated pest management and male annihilation technique for prevention of guava fruit flies are the best method for quality control of guava fruits.

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NUTRITION OF ENTOMOPHAGOUS INSECTS AND THEIR HOSTS, DYNAMICS OF BIO-AGENTS VIS-À-VIS TARGET PEST POPULATIONS

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Abstract

The artificial rearing of parasitoid insects has been instrumental in biological control, enabling the mass production of natural enemies for pest management and providing insights into their biology, physiology, and behavior. This review emphasizes the importance of studying the nutritional requirements of entomophagous insects, which vary by life stage and are crucial for optimizing their effectiveness in Integrated Pest Management (IPM) strategies. Additionally, understanding the population dynamics of natural enemies and their interactions with pest populations is essential for successful biological control. By examining density-dependent mortality and the functional responses of natural enemies, researchers can develop more effective and sustainable pest control solutions, reducing reliance on chemical pesticides and promoting environmental conservation.

Keywords: Entomophagous insects, Parasitoid, Biological control and Natural enemies

Introduction

The artificial rearing of parasitoid insects has been a key development in biological control strategies, enabling the mass production of these natural enemies for pest management. Initially, the goal was to boost parasitoid populations for field release, but the process also provides valuable insights into the biology, physiology, and behavior of these insects, particularly endoparasitoids. Studies show that nutritional needs vary by life stage, with larvae typically requiring more nutrients than adults, except during reproduction phases (Grenier, 1994). This method has advanced biological control by making it possible to study and optimize the conditions for parasitoid effectiveness in pest control programs.

Why evaluation of nutrition needs?

Studying the nutrition of entomophagous insects is important for several reasons, encompassing ecological, agricultural, and human health perspectives:

1. **Biological Pest Control**: Entomophagous insects play a crucial role in biological pest control by preying on other insects, many of which are considered agricultural pests. Understanding the nutritional needs of these predators helps in optimizing their efficiency as natural enemies of pests.
2. **Integrated Pest Management (IPM)**: Knowledge of the nutrition of entomophagous insects is fundamental to the development and implementation of Integrated Pest Management strategies. This approach seeks to combine biological, chemical, and cultural methods to control pests sustainably and minimize the use of chemical pesticides.
3. **Ecosystem Health**: Studying the nutritional ecology of entomophagous insects contributes to our understanding of ecosystem dynamics. These insects are integral components of food webs, and their interactions with other species influence biodiversity and ecosystem stability.
4. **Conservation of Beneficial Insects**: Many entomophagous insects face threats such as habitat loss, pesticide exposure, and climate change. Understanding their nutritional requirements helps in designing conservation strategies to maintain healthy populations, ensuring continued pest control services.
5. **Biocontrol Programs**: Researchers and agricultural practitioners may use entomophagous insects as part of biocontrol programs. By studying their nutrition, scientists can optimize rearing conditions, design effective release strategies, and enhance the overall success of biocontrol efforts.
6. **Human and Animal Nutrition**: Some cultures around the world have traditionally consumed certain entomophagous insects as part of their diet. Studying the nutritional content of these insects can provide insights into their potential as a sustainable and nutritious food source for humans & animals.
7. **Drug Discovery and Medical Research**: Insects, including entomophagous species, produce a variety of bioactive compounds. Studying their nutrition can contribute to the discovery of novel compounds with potential applications in medicine and biotechnology.

8. **Climate Change Impacts**: Climate change can influence the distribution and abundance of insect species, including entomophagous insects. Understanding their nutritional ecology helps in predicting and mitigating potential shifts in insect populations and their effects on ecosystems.

Nutrition of entomophagous insects

Entomophagous insects are those that primarily feed on other insects. They play a crucial role in ecological balance by helping control pest populations. The nutritional content of entomophagous insects can vary depending on factors such as their species, life stage, and diet. Here are some general insights into the nutrition of entomophagous insects:

Protein Content: Entomophagous insects are typically high in protein, as they need this nutrient for growth, development, and reproduction. The protein content can vary among species, with some being more protein-rich than others. Parasitoids and predators are carnivorous species needing a protein-rich diet, with some specific requirements in aromatic amino acids especially in parasitoid diptera at the end of their larval development for cuticle tanning.

Fat Content: Insects, including entomophagous species, often contain significant amounts of fat. The fat content may vary depending on the insect's diet and life stage. The similarity of the composition in total fatty acids of many parasitoids with that of their host, suggests they may copy to a certain extent the host composition polyunsaturated fatty acids may be required for normal growth of several entomophagous insects. Dietary sterols are required by a great number of parasitoid and predators, such as *Exeristes roborator*.

Carbohydrates: Carbohydrates are not as essential for carnivorous insects, as they obtain energy primarily from proteins and fats. It is usually admitted that there are no specific needs for carbohydrates, but glucose promotes growth and lipogenesis, increasing the level of unsaturated fatty acids in *E. roborator*. Trehalose, the most common non-reducing disaccharide in insects, plays an important role in metabolism and stress resistance. It could be used instead of sucrose or glucose, and also partly replaced hemolymph in media for *Trichogramma*. Moreover, sucrose may act as a feeding stimulant on parasitioid, as well as on predator insects.

Other needs

a. **Inorganic salts**: They are generally required for the normal development of insects, but their level and the balance between the different cations, especially K+/Na+ is of prime importance and varies according to the species.

b. **Vitamins**: About 12 vitamins were added in the diets, mainly hydro-soluble ones including B vitamins, as well as C vitamin, and 2 lipo-soluble ones (retinol-A, and tocopherol-e). Commercial preparations are available and often used by many authors, like Van der zant vitamin mixture for insects (van der Zant 1969).

c. **Miscellaneous**: Ribonucleic acids (RNA) are sometimes incorporated in medium/diet, but their dispensability is questionable. RNA could increase survival or promote growth.

Dynamics of bio-control agents vis-a-vis target pest populations

The ultimate goal of biological control is to manipulate and maintain pest populations at low densities and thus prevent problems due to pests. It follows that biological control in long-lived ecosystems can be thought of as a type of ‘‘applied population dynamics”. Information from the majority of population dynamics studies of natural enemies and their interactions with their hosts can have relevance to classical biological control. Information from these studies may also be relevant to conservation biological control in providing the information about correct conditions for optimization of the activity of natural enemies (Rahaman and Zaman, 2022).

Natural Enemy attributes:

Early models suggested several general attributes characterizing successful biological control agents:

- Host specificity,
- Synchrony with the pest,
- High rate of increase,
- Ability to survive periods with few to no prey
- Good searching ability

Such properties are more important for classical biological control or conservation and are more characteristic of parasitoids than predators or pathogens.

Interaction between the population of natural enemies and target pests:

Biological control does not occur when a few hosts are killed but rather when groups of hosts are killed and their populations remain low. Therefore, it is a phenomenon occurring at the population level. Studying populations that vary in space and time is typically more difficult than studying individual organisms. Progress has been made by studying individuals under controlled situations, followed by controlled studies (often experimental) of combinations of the natural enemy and host individuals in the laboratory and the field (Rahaman and Zaman, 2022).

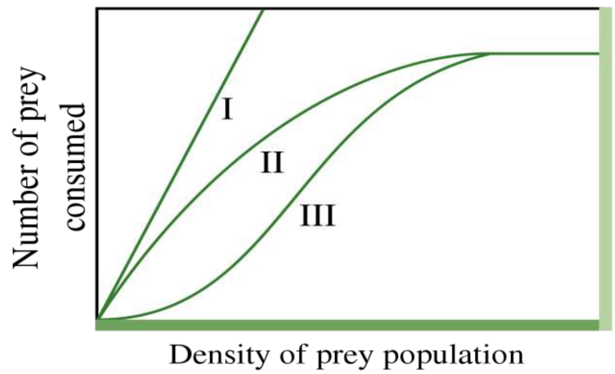

Fig.1: Two types of functional responses by predators to changes in prey abundance, with satiation at high prey densities.

Holling (1966) was instrumental in investigating the changes in predator behavior in response to changes in prey density which he called the functional response. The functional response is the behavioural response of predators to host density and should be differentiated from the numerical response, which involves increasing reproduction in response to prey density. Holling found that as prey density increased, the number eaten increased quickly at first but then slowed, to eventually reach a plateau at satiation (Fig.1, Type 2).This functional response was subsequently found to be characteristic of many invertebrate predators and parasitoids. Response by vertebrate predators was characterized better by a sigmoid response (Fig.1, Type 3).

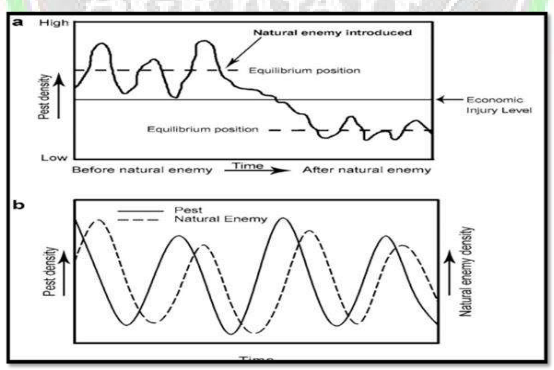

Fig. 2: **a**. **Hypothetical results of a classical biological control introduction in which the average abundance of a pest is reduced after the introduction of a natural enemy, demonstrating stable equilibria both before and after the natural enemy are introduced. (From Flint and Dreistadt, 1998.) b. Hypothetical density-dependent relations in a predator-prey (or natural enemy–pest) system with discrete generations.**

Population regulation involves the control of prey or host populations through natural enemies (e.g., predators, parasites), combining both **exogenous factors** (e.g., natural enemies, climate) and **endogenous factors** (e.g., genetic changes, intra-specific competition) (Fig. 2). Key to this process is density-dependent mortality, where mortality increases as the prey population rises and decreases when it falls, preventing natural enemies from driving prey to extinction (Fig. 2a). This concept was foundational to Nicholson and Bailey's 1935 models of population regulation. However, real-world systems are often density vague, showing trends rather than strict patterns. Another important type is delayed density-dependent mortality (Fig. 2b), where there is a time lag before natural enemy populations increase in response to higher prey densities. This was observed in southern pine beetle populations in Texas, where predator-induced mortality responded with a delay to the beetle's population increase (Rahaman and Zaman, 2022)

Why need to study interaction of natural enemies and pest?

Studying the dynamics of bio-agents in relation to target pest populations is crucial for several reasons

1. **Effective Pest Management:** Understanding the dynamics of bio-agents allows for the development of effective and sustainable pest management strategies. This knowledge helps in optimizing the use of biological control agents to suppress pest populations and reduce the reliance on chemical pesticides.
2. **Integrated Pest Management (IPM)**: Knowledge of bio-agent dynamics is fundamental principles of IPM, which aims to combine various pest control methods in a coordinated and environmentally friendly manner. Bio-agents play a key role in IPM, and understanding their interactions with target pests is essential for successful implementation.
3. **Reduction of Pesticide Use**: Biological control through the use of bio-agents offers an alternative to chemical pesticides. By studying the dynamics of bio-agents, researchers can contribute to the development of sustainable pest management practices that reduce the overall reliance on synthetic chemicals, minimizing environmental impact.
4. **Conservation of Natural Enemies**: Understanding the factors that influence the population dynamics of bio-agents helps in the conservation & enhancement of natural enemies in agroecosystems. This, in turn, contributes to the maintenance of biodiversity and the stability of ecosystems.
5. **Environmental Conservation**: The use of bio-agents provides environmentally friendly & sustainable agricultural practices. It helps to reduce the environmental impact associated with

the use of chemical pesticides, including pollution of water bodies and harm to non-target organisms.

Conclusion

During several decades, many successes were obtained in different countries around the world, mainly with idiobiontic parasitoids and polyphagous predators. Approximately 130 entomophagous species have been partly or completely reared in artificial diets, among them more than 20 species of Trichogrammatidae. Entomophagous insects play a crucial role in biological pest control by preying on other insects, many of which are considered agricultural pests. Understanding the nutritional needs of these predators helps in optimizing their efficiency as natural enemies of pests. Ongoing monitoring and assessment of both bio-agents and target pest populations are crucial for understanding the dynamics and adjusting management strategies as needed.

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CONTRIBUTION OF SUBTERRANEAN INSECTS IN SOIL

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Introduction

Subterranean insects play a vital role in ecosystems and agriculture. These underground dwellers contribute to soil health, nutrient cycling and pest control, making them valuable allies for sustainable agriculture. Underground insects can also help reduce greenhouse emissions and soil carbon sequestration. Another use of subterranean insects as bioindicators of soil health and environmental quality. Subterranean insects support the soil conditions, which include moisture, temperature, organic matter and oxygen availability.

Termites

Termites create mounds and galleries that have drastically changed physical characteristics due to the way they repack soil, adding organic material from their faeces and saliva. An increase in accessible phosphorus and stabilisation of soil organic matter improve cation exchange capability in mound materials.

The termite mound's organic matter is extremely rich in nitrogen, phosphorus and sulphur. These elements support the growth of helpful microbes, including sulphur oxidiser, fixers of nitrogen and decomposers of phosphorus. Termite mound soil increases the crop yield and can be used as biofertilizer.

Mole cricket

It appears that mole cricket activity increases with soil moisture levels and decreases significantly with lower soil moisture levels. It digs the tunnels, improving soil structure and aeration. They break down organic matter, releasing nutrients for plant uptake. It mostly prefers moist and sandy loam soils.

Nematode

Nematodes graze on bacteria that break down organic matter, release ammonia and immobilise nitrogen in living biomass, all of which indirectly aid in the mineralisation of nitrogen. Increased availability of nitrate and ammonium is associated with successional maturity of nematode communities in cultivated mineral soils for agricultural purposes.

Dung beetle

Dung beetles play important roles in ecosystems by promoting the decomposition of manure, enhancing the cycling of nutrients and affecting the physical and chemical characteristics of soil, such as pH and accessible nutrients. Dung decomposition slows, nutrient cycling fails and water infiltration lowers in the absence of dung beetles.

In sandy soils, dung beetles are more common and active. Dung beetles have a significant role in soil ecology with regard to the nitrogen cycle and greenhouse gas emissions.

Drought conditions cause plants to respond by improving plant growth (280%), leaf emergence (30%) and plant height (200%) in response to increased soil moisture caused by dung beetle activity.

Ants

Ants play an important role in enrichment of the soil next to earthworms. Soil from beneath plants with ant nests contained significantly higher concentrations of nitrate, ammonium, phosphorus and water than soil from beneath plants without nests.

Ants also increase the amount of nitrogen in their stomach. But throughout the nest building process, these gut bacteria are introduced to the soil, which results in rich nitrogenous topsoil and subsoil. Plant growth and development are ultimately aided by this process.

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REVIEW ON BABESIOSIS IN FELINES

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Abstract

The disease feline babesiosis in cats is a serious tick-borne illness which is caused by infection with the *Babesia* parasite. *Babesia felis* , first discovered in wild cats in Sudan, has been found to cause illness in domestic cats. Babesia is spread through the bite of an infected tick belonging to the Ixodes tick family. Although Ixodes ticks are present all over the world, they are more prevalent in Southern Asia and sub-Saharan Africa and are the carriers of feline babesiosis. Babesiosis is typically manifests in cats as tiredness, lethargy, poor appetite, weight loss and pale gums. Diagnosis involves physical and hematological examination. Confirmatory diagnosis includes identification of *Babesia* sp. through microscopic examination of blood smear or specialized testing. Antiparasitic medication along with symptomatic treatment of anemia such as fluid therapy and blood transfusions are the treatment options. The severity of anemia and how well the animal responds to treatment determines the prognosis.

Keywords: Babesiosis, *B. felis*, Ixodid tick, Anemia, Antiparasitic medication.

Introduction:

Babesiosis is a tick-borne disease caused by protozoan parasites from the genus Babesia, which are part of the Piroplasmida group. The condition is named after Romanian bacteriologist Victor Babes. It is also referred to as piroplasmosis, deriving from the Latin words "pirum," meaning "pear," and "plasma," meaning "image formation." This disease affects both domestic and wild animals, as well as humans, globally. In addition to various wild and domestic mammals, cattle, horses, sheep, goats, pigs, cats, and dogs are also susceptible to the disease

(Phillip *et al*., 2022). While it is commonly recognized in dogs worldwide, it occurs only infrequently in cats (Katrin Hartmann *et al*., 2013). Babesia species that infect cats are more resistant to antiparasitic drugs compared to those affecting dogs, which can make treatment less effective for some cats (Vetster,, 2023). Most reported cases indicate that infections primarily occur in younger cats, with no specific breed or gender showing a higher susceptibility (Michael, 2022). The aim of this manuscript is to review and summarize information regarding the etiology, clinical symptoms, diagnosis, treatment, prognosis and prevention of feline babesiosis.

Etiology and Lifecycle:

Babesia are intracellular protozoan parasites belonging to the phylum Apicomplexa and the order Piroplasmida. Most cases of *B. felis* related illness in domestic cats, along with *B. leo*, *B. lengau*, and other less well-defined species, have been documented in southern Africa (Phillip *et al*., 2022). Although specific transmission studies in cats are lacking, it is assumed that all babesial species are transmitted through a tick vector. Ticks from the genera *Ixodes*, *Dermacentor*, *Rhipicephalus*, *Amblyomma*, and *Haemophysalis* are known to infest cats and are likely involved in the transmission of the disease (Shaw *et al*., 2001). The parasite is taken in by a tick during feeding and replicates within it. If the tick is female and carries eggs, the parasite can affect those eggs. When the tick bites the cat, it regurgitates digestive enzymes to prevent the cat’s blood from clotting, allowing it to continue feeding. During this regurgitation that the disease is transmitted to the cat. Once in the cat’s bloodstream, the parasites attach to red blood cells, multiply, and eventually rupture the cells, spreading to infect more cells. This often leads to anemia (blood loss) within a few weeks, which can result in symptoms like low energy and appetite, as well as other serious, potentially life-threatening complications (Michael, 2022).

Clinical Symptoms:

Initially, symptoms are usually mild and can worsen as the protozoa multiply in your cat. Additionally, it might take a while for symptoms to appear after the initial infection (Jacobson *et al*., 2000). Anorexia, lethargy, weakness, muscle tremors, rapid heart rate, rapid respiratory rate and a rough haircoat are typical clinical symptoms. Fever and icterus are less common than in dogs. Mostly the fever cases have a coexisting illness . The majority of clinical symptoms are a consequence of hemolytic anemia, which is caused by piroplasms infecting erythrocytes. Cats with anemia typically manage it well and may exhibit few clinical symptoms. Complications of babesiosis can include kidney failure, pulmonary edema, liver disease, and neurological issues.

Co-infections with Mycoplasma hemofelis, feline leukemia virus (FeLV), or feline immunodeficiency virus (FIV) can worsen the clinical presentation and disease severity (Katrin Hartmann *et al*., 2013).

Diagnosis:

A tentative diagnosis of babesiosis may be made based on clinical features and medical history; however, comparable clinical indications might also be caused by other illnesses. To confirm the diagnosis, Giemsa-stained blood or organ smears must be examined under a light microscope. This method is quick and cost-effective, but it requires some expertise. Blood smears should be taken from capillaries, such as the ear or tail tip, to enhance detection sensitivity (Michael, 2022). Detecting Babesia spp. in the carrier state or during chronic infection may be possible with molecular techniques like PCR tests, which are more sensitive than light microscopy. Additionally, isolates are characterized and differentiated using molecular techniques. Serologic tests have been developed to detect antibodies against Babesia spp. in carrier animals, with the indirect fluorescent antibody test and ELISA being the most commonly used. However, these tests are not effective for diagnosing the acute stage of illness (Phillip *et al*., 2022).

Treatment and Prognosis:

Primaquine phosphate, an anti-malarial medication, has been shown to be effective in treating babesiosis (Michael, 2022). Additionally, antiprotozoal drugs like imidocarb dipropionate are also used. Supportive care may be necessary based on the severity of the infection and observed clinical signs. This care can anti-inflammatory, blood transfusions, IV fluids, and appetite stimulants (Katrin Hartmann *et al*., 2013).

The severity of anemia at presentation, the specific species of Babesia infection present, and the cat's general condition at the time of infection all affect the prognosis. Most cats show improvement within 1-2 weeks of treatment, but blood work is necessary to monitor anemia and for successful treatment. Some Babesia species may be resistant to antiparasitic medications, leading to treatment failure or relapse, and certain cats may become lifelong carriers of the parasite despite treatment (Vetster, 2023).

Prevention:

Experimental use of soluble parasite antigens from several Babesia species has been attempted as a vaccine to combat the clinical effects of babesiosis, showing mixed success in cattle and dogs. However, there are currently no vaccines available for cats (Katrin Hartmann *et al*., 2013). Tick prevention medications are often combined with flea treatments to create a two-in-one preventative solution. Because cats cannot tolerate permethrin, alternative treatments such as fipronil should be used (Vetster, 2023). These parasite-control products are available in different forms including topical ointments, collars, and oral medications (Sam, 2022).

Conclusion

The prevalence of Babesia is influenced by the geographical distribution of the ticks that carry it. Most cats affected by babesiosis can fully recover with proper adherence to their medication and a preventive treatment plan. However, if left untreated, they may face complications primarily due to anemia, as well as potential issues like kidney disease, respiratory distress, and liver problems.. Since Babesia species are spread by various tick species, effective tick control is the best method for preventing the infection.

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RESPONSE OF PLANTS TO ELEVATED UV RADIATION

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Introduction

Ultraviolet radiation is a portion of the electromagnetic spectrum classified into three main categories: UV-A (320–400 nm), UV-B (280–320 nm), and UV-C (100–280 nm). The UV radiation from the sun that crosses the atmosphere and reaches the earth's surface is composed largely of UV-A radiation (95%) and, to a lesser extent, UV-B (5%), which is normally filtered by stratospheric ozone. With the thinning of the ozone layer, UV-B radiation penetrates deeper into the earth's surface, where it becomes dangerous due to its high energy content that acts at the molecular level, affecting the cycles of carbon, nitrogen, and other elements, thus, having a direct impact on global warming. On the other hand, UV radiation alters numerous essential organic compounds for living organisms. Since its discovery, it has been established that UV-B causes alterations in plant development and metabolism, both primary and secondary. The effects of UV radiation on plants are:

DNA Damage

Ultraviolet radiation is efficiently absorbed by most organic substances, which causes many photochemical reactions in the living cells. The nucleus of each cell consists primarily of genetic material in the form of DNA. Nuclear DNA is inherently unstable and can be damaged by spontaneous or metabolically induced changes generated by environment. DNA is highly sensitive to UV-B radiation which can cause damage resulting in heritable mutations if not repaired and thus, can significantly influence various physiological processes. DNA is considered the primary absorbing compound in the cell in the UV-B region of the spectrum.

Exposure of DNA to UV-B radiation can result in:

- Breakage of bonds in the DNA and DNA-protein cross links;
- Chromosomal breakage;
- Chromosomal aberrations; and
- Exchange and production of toxic and mutagenic photoproducts (e.g., cyclobutane pyrimidine dimmers (CPDs), 6, 4 pyrimidine- pyrimidone or 6, 4-photoproduct, thymine glycols, and pyrimidine hydrates).

These changes in DNA alter transcription, replication, and recombination of genes and cause significant changes in plant metabolic and genetic processes. Proteins, membrane lipids, and other essential substances in the cell can also be altered through exposure to UV-B radiation, resulting in protein degradation and lipid peroxidation. These damages influence genetic makeup and affect protein synthesis, enzyme activities, and gene expression. All cellular life-forms possess DNA repair enzymes that recognize chemically modified bases, including those formed by UV radiation. Furthermore, cells have evolved through a variety of biochemical mechanisms to restore the integrity of the genetic material after DNA damage and retain its stability. These processes are called "DNA repair mechanisms."

Photosynthesis

Photosynthesis is the process by which plants convert carbon dioxide and water into carbohydrate in the presence of sunlight. The photosynthetic apparatus is one of the important target sites of UV-B damage. Direct effects of enhanced UV-B radiation on photosynthesis include:

- Damage to ultrastructure of chloroplasts that are principal sites for photosynthesis;
- Impairment of light energy transfer (i.e., electron transport system of photosystem II (PS II) and to a lesser extent, photosystem I (PS I);
- Decrease in activity of Ribulose 1, 5-bisphosphate carboxylase/oxygenase (Rubisco);
- Decreased carbon dioxide fixation and oxygen evolution; and
- Decreased starch and chlorophyll content.

Components affected in PS II are the water oxidizing system, light-harvesting complex, and synthesis of chlorophyll a/b binding proteins. Exposure to UV-B radiation decreases both activity and concentration of Rubisco. UV-B inactivation of Rubisco could mainly be due to modification of the peptide chain, degradation of the protein, and/or diminished transcription of the gene.

In addition to the direct effects of UV-B radiation, photosynthesis may also be indirectly affected by:

- Induction of stomatal closure;
- Decreased individual leaf area and total canopy leaf area;
- Changes in thickness and anatomy; and
- Changes in canopy architecture and morphology. All these changes can potentially decrease light interception and gas exchange, which results in lower canopy photosynthesis.

However, the stomatal closure mechanism reduces evapotranspiration water losses and increases water use efficiency, which leads to increased plant growth and yield.

Morphology and Architecture

Although UV-B radiation constitutes a small portion of the solar spectrum, it induces a range of strong morphological effects in plants, including leaf thickness, leaf discoloration, cotyledon curling, inhibition of hypocotyl growth, stem and leaf elongation, axillary branching, and shifts in root-shoot ratio. In most plant species, leaves exposed to UV-B radiation initially develop irregular patches. With continued exposure to UV-B radiation, these chlorotic patches become brown necrotic spots and die. The appearance of chlorotic and necrotic patches is generally attributed to decreases in leaf chlorophyll content. Elevated UV-B radiation can result in slower stem extension rates, shorter internode lengths leading to shorter plant height, decreased individual leaf size, fewer leaves leading to less leaf area, and fewer tillers and branch lengths. Overall, these morphological changes result in a smaller canopy. Plant architecture is modified by UV-B radiation. When exposed to UV-B radiation both attached and detached tendrils of pea plants form spiral coils. In addition, enhanced UV-B radiation causes increased leaf epicuticular wax and stomatal index, and reductions in thickness of palisade and mesophyll tissues without altering the thinness of the epidermal layers.

Growth & Development

Exposure to UV-B radiation caused decrease in growth of leaves and stems in many plant species in both controlled environment and field studies. However, the effects of UV-B radiation on plant growth and dry matter accumulation were generally smaller under field conditions than under controlled environmental conditions. The decrease in growth of leaves, main stem, and branches is due to reduced cell division rather than decreased cell size. Reduction in plant height from exposure to UV-B is due inpart to decreased levels of a growth hormone (Indole Acetic Acid) in plants. The smaller and more compact canopy reduces the amount of UV-B intercepted by the plant, but also reduces the potential or total photosynthetic area essential for growth. The combination of these various factors results in decreased total dry matter or biomass production.. In regard to exposure to UV-B radiation, the majority of crop species (60%) show a reduction in dry matter production, a moderate 24% show no change, and only 8% of crop species show an increase in dry matter production.

Elevated UV-B radiation can delay flowering time in several different crops. However, in some crops, UV-B radiation does not influence early bud or flower development, or the time to first flower. UV-B radiation does affect flower size, anther number, and pollen production, germination, and tube growth in many plant species. Cotton (*Gossypium hirsutum* L.) flowers produced on plants exposed to elevated UV-B were smaller due to reduced petal and bract size, and had fewer anthers. In general, reproductive organs of most plant species (pollen and ovules) are highly protected by sepals, petals, and ovary walls. In these plants, pollen is susceptible after it falls on the stigma.

Yield and Quality

Yield is the economic product harvested from plants (e.g., grain from wheat (*Triticum aestivum* L.), seeds from pods of soybean, roots from carrot, seed and lint from cotton). Similar to changes in dry matter production, change in yield of crop species from exposure to UV-B varies with species. Some species (e.g., pea, barley, and mustard show severe reduction; others (e.g., cowpea, millets, and tobacco) show less or no yield reduction. The main causes of yield loss are reduced fruit (grain) number due to failure in fertilization, abortion of fruiting structures, and decreased fruit size due to reduced supply of assimilates to the growing sink (fruits). These differential responses were due to variability in intensity of UV-B radiation. In addition, the variable responses can also be due to differences in responses of cultivar and crop species to UV-B radiation. Ultraviolet-B radiation also affects the quality of the economic product. For example, seed oil and protein content in soybean are reduced on exposure to UV-B radiation. Enhanced UV-B radiation decreased grain size and increased total nitrogen and storage protein (glutelin), thus affecting the taste of food products.

Pest Damage

The impact of elevated UV-B radiation on plant species is well understood, but knowledge of the effects of UV-B on insect pests and disease-causing pathogens (fungi and bacteria) is limited. Research conducted thus far has shown both a decrease and an increase in disease and pest damage in response to increased UV-B radiation. Effects of UV-B on diseases and insects could be attributed to direct effects on their growth and indirect effects through changes in tissue characteristics and/or composition. Solar UV-B can affect insect herbivores through reduced growth, survivorship, and fecundity through changes in leaf characteristics (appearance and composition). Insects can perceive UV-B radiation, modify their behavior to avoid UV-B radiation, and protect themselves by regulating their cuticular pigmentation to screen damaging wavelengths. Studies demonstrated that thrips consumed less leaf tissue and Lepidopeteran larvae had lower survivorship in laboratory assay when fed on leaves grown under near-ambient solar UV-B compared with leaves from UV-B excluded plots.

The lower larvae survival was attributed to higher levels of soluble phenolics and lower lignin content in the foliage exposed to UV-B radiation. Similarly, bioassay studies suggested that adult specimens of leaf beetles tend to preferentially feed on plants not exposed to UV-B if given the opportunity to choose between UV-B exposed and unexposed plant materials. However, the impact of UV-B radiation on mechanisms of other behavior of adult insects, such as oviposition and breeding, that are more relevant under natural conditions are not well understood and need investigation. Ultraviolet-B radiation changes the chemistry, morphology, and physiology of plants. This can directly influence pest and disease incidence. For example, UV-B can affect leaf nitrogen content, available carbohydrate, and fiber indirectly influencing insect growth and survival. Plants exposed to UV-B can also stimulate production of secondary metabolites, i.e., phenolics and jasmonic acid which can influence insect incidence or behavior by acting as either a deterrentor attractant. Some insects protect themselves from UV-B radiation by feeding on the underside of the leaves where UV-B penetration is lower and avoiding areas of plants where defensive chemicals accumulate.

The effect of UV-B on plant pathogens can occur either through direct effects on various stages of pathogen development, such as spore germination, germ tube extension or indirectly by influencing host-plant resistance by damaging cells, decreasing plant growth and morphology (decreasing leaf and cuticle thickness), or modifying gene expression.

However, it is very difficult to differentiate the effects of UV-B radiation on the host from those on the pathogen itself under field conditions.

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BLOOD TRANSFUSION IN SMALL RUMINANTS

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Introduction

Blood transfusions, though more commonly associated with human medicine, are also critical in veterinary care, including in small ruminants (sheep and goats). Anemia in small ruminants can result from a variety of causes, and in severe cases, blood transfusions can be life-saving. This article provides an overview of the aim of blood transfusion in small ruminants, the causes of anemia, the treatment approach, and how it can benefit farmers.

1. Aim of Blood Transfusion in Small Ruminants

The primary aim of blood transfusion in small ruminants is to restore adequate oxygen-carrying capacity, improve tissue perfusion, and stabilize critical anemic patients (Fig:1). Blood transfusions help:

1. **Correct severe anemia:** by increasing red blood cell count.
2. **Provide symptomatic relief**: from signs of oxygen deficiency, such as weakness, lethargy, and respiratory distress.
3. **Support the immune system:** by replacing essential blood components, especially in animals with compromised immunity due to infection or disease.

The use of blood transfusion as a therapeutic measure is crucial when immediate intervention is needed to prevent organ damage or death.

2. Causes of Anemia in Small Ruminants

Anemia in small ruminants can be caused by various factors, including:

a. **Parasite Infestation**: Gastrointestinal parasites (e.g., Haemonchus contortus) are a leading cause of anemia in sheep and goats, particularly in regions where pasture management is poor. The parasites feed on the blood, leading to significant blood loss.

b. **Hemorrhage**: Traumatic injury, internal bleeding from conditions like abomasal ulcers, or post-partum hemorrhage can cause acute blood loss.

c. **Hemolytic Anemia**: Diseases such as leptospirosis or copper toxicity can destroy red blood cells (hemolysis), leading to anemia.

d. **Nutritional Deficiency**: Deficiencies in essential nutrients like iron, copper, and vitamin B12 can impair red blood cell production, causing anemia.

e. **Chronic Disease**: Conditions like liver disease, kidney failure, or chronic infections can suppress bone marrow function, reducing red blood cell production.

Fig 1: Pale mucous membrane due to anaemia

3. Treatment of Anemia in Small Ruminants

Treatment of anemia in small ruminants is two-fold: addressing the underlying cause of the anemia and stabilizing the animal’s condition.

a. **Blood Transfusion**: Blood transfusion is the treatment of choice in acute cases of anemia (Fig :2) where immediate correction of red blood cell levels is necessary. Whole blood is typically used, and cross-matching is done to avoid transfusion reactions.

b. **Antiparasitic Therapy**: In cases of parasitic anemia, deworming with appropriate anthelmintics (e.g., ivermectin, fenbendazole) is necessary to kill the parasites. This treatment may be accompanied by blood transfusions in severe cases.

c. **Supportive Care**: Providing iron supplements, vitamin B12, or copper injections may be necessary in cases of nutritional anemia.

d. **Fluid Therapy**: In cases of blood loss or dehydration, fluid therapy is often used alongside transfusions to stabilize the animal.

e. **Surgical Intervention**: In cases where anemia is caused by internal bleeding or trauma, surgery may be needed to stop the hemorrhage.

Fig2: Blood Transfusion in goat

4. Utility of Blood Transfusion to Farmers

For farmers, maintaining the health of small ruminants is critical for economic sustainability. Blood transfusion as a therapeutic option can significantly benefit farmers by:

a. **Saving Lives**: Blood transfusions can prevent death in severely anemic animals, thus protecting the farmer's investment.

b. **Enhancing Productivity**: Healthy animals are more productive in terms of milk, wool, and meat. Treating anemia restores the animal's strength and vitality, ensuring they return to full productivity.

c. **Reducing Losses**: Quick and effective treatment of anemia can prevent the long-term effects of chronic illness, which can result in poor growth, reproductive failure, and decreased market value.

d. **Minimizing the Need for Euthanasia**: In cases of severe anemia, where traditional treatment might be insufficient, a blood transfusion can prevent the need to euthanize valuable animals.

e. **Contributing to Herd Health**: Using advanced treatment options like blood transfusions reflects a proactive approach to animal health, which can enhance herd resilience and improve overall farm efficiency.

Conclusion

Blood transfusion in small ruminants is a critical tool for treating severe anemia resulting from various causes, including parasitic infestations, hemorrhage, and chronic disease. For farmers, this intervention can be a life-saving procedure that not only ensures the health and productivity of individual animals but also supports the economic sustainability of the farm. With proper veterinary guidance, the use of blood transfusion in small ruminants can be a practical and effective solution for managing anemia and improving overall herd welfare

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PROTECTING INDIAN AGRICULTURE: THE EVOLUTION AND IMPACT OF CROP INSURANCE

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Introduction

Agriculture is a cornerstone of the Indian economy, employing over 50% of the workforce and contributing significantly to the national GDP. Despite its importance, the sector is highly susceptible to various risks such as adverse weather conditions, pest attacks, and market fluctuations. Crop insurance emerged as a critical tool to mitigate these risks, providing financial protection to farmers and contributing to the stability of the agricultural sector.

Historical Evolution of Crop Insurance in India:

The concept of crop insurance in India dates back to the 1970s, but it was only in the 1980s that formal schemes began to take shape. The National Agricultural Insurance Scheme (NAIS) was introduced in 1999 to provide a safety net for farmers against crop loss. This scheme marked the beginning of a structured approach to crop insurance in India, aimed at reducing farmers' vulnerability to various risks (Rao, 2002).

Overview of Important Crop Insurance Schemes in India:

1. **National Agricultural Insurance Scheme (NAIS):** NAIS, launched in 1999, was a pioneering initiative to offer insurance coverage for crops. It provided protection against both natural calamities and crop failures due to pest attacks. However, the scheme faced criticism for its limited coverage and delayed claim settlements (Singh, 2006).
2. **Modified NAIS (MNAIS):** In response to the shortcomings of NAIS, MNAIS was introduced in 2010. This scheme aimed to improve coverage and enhance the speed of claim processing. It also incorporated the concept of localized risk assessment and area-specific insurance plans (Sharma, 2013).

3. **Pradhan Mantri Fasal Bima Yojana (PMFBY):** Launched in 2016, PMFBY is the most recent and ambitious crop insurance scheme. It aims to provide comprehensive coverage against all natural calamities, including localized risks. PMFBY also seeks to address issues of affordability and accessibility, with premium subsidies and simplified claim processes (Government of India, 2016).

Importance of Crop Insurance in Protecting Farmers:

Crop insurance plays a vital role in protecting farmers, ensuring food security, and strengthening rural economies:

- Crop insurance provides a financial safety net for farmers against losses caused by natural disasters, weather events, and market fluctuations. It helps reduce farmers' stress and keeps them motivated to continue farming.
- It maintains price stability in the agricultural sector by safeguarding farmers' incomes and providing stability in the face of unpredictable conditions, facilitating a consistent and affordable food supply for consumers.
- Crop insurance promotes food security by supporting farmers of all sizes and financial situations, with plans ranging from individual-field to whole-farm to county-based coverage to ensure accessibility for farmers across the country.
- It strengthens rural economies by incentivizing environmental initiatives, maintaining actuarial soundness, and investing billions of dollars in rural communities through hiring employees, contracting with agents, and expanding technologies.
- Crop insurance encourages farmers to adopt more sustainable and efficient farming practices, as certain insurance policies offer better terms for employing risk-reducing practices. This leads to a more environmentally friendly approach to agriculture.
- It enables farmers to make more confident decisions about planting and investment, knowing they have a financial backup in case of unforeseen circumstances.
- Crop insurance has a significant positive impact on farmers' income, especially in areas with lower agricultural insurance density and lower per capita insurance indemnities.

Technological Advancements in Crop Insurance:

i. **Use of Satellite Imagery and Remote Sensing for Crop Monitoring:**

Technological advancements, such as satellite imagery and remote sensing, have revolutionized crop monitoring. These tools provide accurate data on crop health and weather conditions, enhancing risk assessment and claim management (Rani, 2024).

ii. **Role of Mobile Technology and Digital Platforms:**

Mobile technology and digital platforms have improved access to crop insurance services. Farmers can now receive real-time information, process claims, and manage policies through mobile apps and online platforms (Kumar, 2023).

iii. **Innovations in Weather Forecasting and Risk Assessment:**

Advanced weather forecasting techniques and risk assessment models help in better predicting and managing agricultural risks. These innovations contribute to more accurate and timely insurance coverage (Jain, 2023).

iv. **Adoption of Data Analytics and Artificial Intelligence:**

Data analytics and artificial intelligence are being increasingly used to analyze risk factors, predict crop yields, and optimize insurance coverage. These technologies enhance the efficiency and effectiveness of crop insurance schemes (Sinha, 2024).

Extent of Coverage and Penetration Among Farmers:

Despite the introduction of several schemes, the extent of coverage and penetration remains limited. Various factors, including lack of awareness, complex procedures, and inadequate infrastructure, contribute to low enrolment rates among farmers (Joshi, 2018).

Regional Variations in the Uptake of Crop Insurance:

There are significant regional variations in the uptake of crop insurance across India. States with better infrastructure and higher levels of awareness tend to have higher coverage rates, while others lag behind. For example, states like Maharashtra and Karnataka have seen relatively higher insurance penetration compared to less developed regions (Mishra, 2020).

Role of Government and Private Insurance Companies:

The government plays a crucial role in formulating policies, subsidizing premiums, and ensuring the smooth operation of crop insurance schemes. Private insurance companies are responsible for underwriting risks, managing policies, and processing claims. Collaboration between these entities is essential for the success of crop insurance programs (Sinha, 2022).

Economic Impact of Crop Insurance:

Financial Stability and Risk Mitigation for Farmers:

Crop insurance provides a financial cushion for farmers facing crop failures, thereby reducing their vulnerability to economic shocks. It helps in maintaining a steady income flow, even during adverse conditions, which is critical for the financial stability of farming households (Reddy, 2019).

Impact on Agricultural Productivity and Investment:

Insurance coverage encourages farmers to invest in improved agricultural practices and technologies. By mitigating the financial risks associated with crop failures, insurance schemes enable farmers to adopt new methods and increase productivity (Verma, 2021).

Impact of Climate Change and Extreme Weather Events:

Climate change poses a growing challenge to crop insurance, with increased frequency and intensity of extreme weather events. Insurance schemes need to adapt to these changing conditions to provide effective coverage.

Role in Reducing Poverty and Enhancing Rural Development:

By providing a safety net against crop losses, crop insurance contributes to poverty alleviation and rural development. It helps improve the economic conditions of farming communities and supports their overall well-being (Patel, 2017).

Challenges and Issues in Crop Insurance:

i. **Awareness and Accessibility Issues Among Farmers:**
One of the major challenges in crop insurance is the lack of awareness among farmers. Many are unaware of the benefits and procedures of insurance schemes, leading to low participation rates (Mohan, 2021).

ii. **Affordability of Premiums and Financial Constraints:**
The cost of premiums remains a significant barrier for many small and marginal farmers. Despite subsidies, the financial burden of insurance can be prohibitive for some, limiting their ability to enroll (Nair, 2023).

iii. **Operational Challenges Such as Claim Processing and Fraud:**
Operational inefficiencies, including delays in claim processing and instances of fraud, undermine the effectiveness of crop insurance schemes. Addressing these issues requires improvements in administrative processes and increased transparency (Rao, 2020).

Recommendations for Enhancing Crop Insurance:

i. **Strategies for Increasing Awareness and Participation:**
To increase awareness and participation, targeted outreach programs, farmer education initiatives, and simplified procedures are essential (Mohan, 2024).

ii. **Suggestions for Improving Policy Design and Implementation:**

Improving policy design involves addressing issues such as affordability, simplifying claims processes, and ensuring timely disbursement of benefits (Sharma, 2024).

iii. **Recommendations for Leveraging Technology and Innovation:**

Leveraging technology involves adopting advanced data analytics, remote sensing, and mobile platforms to enhance insurance services and risk management (Rani, 2024).

iv. **Proposals for Strengthening Stakeholder Collaboration:**

Strengthening collaboration among government agencies, insurance companies, technology providers, and farmers will enhance the effectiveness of crop insurance schemes (Sinha, 2024).

Conclusion

Crop insurance has evolved significantly in India, with various schemes addressing the needs of farmers and contributing to agricultural stability. Despite challenges, technological advancements and policy reforms hold promise for enhancing the effectiveness and coverage of crop insurance. Continued efforts are needed to address existing issues, leverage innovations, and expand coverage to ensure that crop insurance remains a robust tool for protecting Indian agriculture.

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RECENT TREND ADVANCES OF MICROBIAL INSECTICIDES IN PEST MANAGEMENT

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Introduction

By 2100, there will be 10.12 billion people on the planet. Presently, the ideal pesticide is considered to have the high selectivity to target species with low toxicity to non-target organisms, high effectiveness at low application rate and should have low environmental diligence or biodegradable to prevent bioconcentration and biomagnification within the food chain. Microbial insecticides are particular types of pesticides that are made from substances that exist naturally like bacteria, plants, animals, and minerals. These biological insecticides provide an effective and environmentally friendly means to deal with pest issues because they are based on infectious microorganisms unique to a target pest.

Bio-pesticides:

Biopesticides are naturally occurring substances emanating from living creatures such as fungi, bacteria, viruses, algae, nematodes, and protozoa or their products, including as phytochemicals and microbes or their by-products, such as semiochemicals, which can control pests by nontoxic means.

Bacterial Insecticide:

Bacteria in the rod-shaped genus **'Bacillus'** are the bacterial pathogens employed to control insects. They are poisons that will affect the stomach of the target animals. Bt-treated foliage (which comprises spores and crystalline poison) is consumed by caterpillars. The caterpillar stops feeding when the toxin attaches to particular receptors in the gut wall in a matter of minutes. The poison dissipates in a matter of hours when the gut wall disintegrates, allowing spores and healthy gut bacteria to enter the internal cavity. The caterpillar contracts septicemia within one to two days, causing spores and gut bacteria to multiply in its blood.

1. **Bt chemicals that eradicate caterpillars**: A strain of *Bacillus thuringiensis* called *Bacillus kurstaki* is grown to generate the most prominent and extensively used Bt insecticides. For these commercial products, the most prevalent trade names include Bactosporine®, SOK-Bt®, Thuricide®, Dipel®, Javelin®, Worm Attack®, and Caterpillar Killer®.
2. **Bt formulations that eliminate the larvae of fungus gnats, black flies, and mosquitoes:** In the early 1980s, research into synthesizing a second class of Bt insecticides got undertaken. *Bacillus thuringiensis var.israelensis (Bti)* is used in these goods. *Bti* does not regulate the larval stages of "higher" flies, such as the house fly, stable fly, etc. Its primary focus is the larval stages of mosquitoes, black flies, and fungus gnats. Products featuring Bt that exist commercially consist of Skeetal®, Mosquito Attack®, Bactimos®, Vectobac® , Teknar®.

The core components of entomopathogenic bacteria, delta endotoxins and vegetative insecticidal proteins (VIPs) are thought to be considerably for humans and non target organisms than the majority of standard insecticides because they attack sites that are peculiar to specific insect groups. The vast majority of organic certification systems accept commercial *B. thuringiensis* insecticides since they are designated by the EPA as Generally Regarded as safe (GARS). In excess of 40 Bt products, including Montery B.t. ®, Mosquito Dunks®, and LARVECT 50®, are on the market to combat beetles, caterpillars, and blood-feeding flies like mosquitoes. When utilized together, they constitute 1% of the market for insecticides.

Table 1: A list of a few notable bacterial insecticide

Target insects	Bacterial Insecticide
Lepidoptera	*Bacillus thuringiensis sub-species kurstakia*
Lepidoptera	*B. thuringiensis sub-species aizawaia*
Coleoptera: Scarabaeidae	*B. thuringiensis sub-species japonensis*
Coleoptera: Scarabaeidae, *Popillia japonica*	*Paenibacillus popilliae*

Fungal Insecticides:

Over the past several decades, the use of entomopathogenic fungi as biological insecticides for insect species has garnered attention on a global scale. Fungal pathogens exhibit superior performance in environments with relative humidity levels over 80%. Naturally occurring mycoparasites are predicted to be important in the control of pests in tropical and subtropical areas with humid weather. Asexual spores termed conidia are the route of transmission for the majority of insect disease-causing species. UV radiation and desiccation are major factors in the death of many species of fungi, despite the fact that the conidia of various species can withstand quite diverse environmental conditions. Very high humidity or free water are typically needed for germination when viable conidia land on a vulnerable host.

1. ***Beauveria bassiana***: This ubiquitous soil fungus can infect a wide range of hosts, such as fire and many beetles. It affects several species' adults as well as their larvae. Currently, this fungus is being prepared for EPA registration by one or more companies. The secret to effectively using *Beauveria bassiana* may lie in grasping how it interacts with other soil microbes. Some insecticide includes balEnce™ Fly Spray 15 oz Bottle , BioCeres EC, BioCeres WP, BotaniGard® 22WP, BotaniGard® ES, BotaniGard® MAXX, Mycotrol® ESO, Mycotrol® WPO to control pests.
2. ***Verticillium lecanii:*** This fungus was formerly marketed under the trade name Vertelec® and was used to suppress whiteflies and aphids in greenhouses.
3. ***Hirsutella thompsonii:*** This pathogen is no longer commercially available, despite some preparations being registered by the US EPA and sold under the trade name Mycar®. The pathogen of the citrus rust mite is called *Hirsutella thompsonii.*
4. ***Metarhizium anisophilae:*** The most popular hyphomycete entomopathogenic fungi for controlling insect pests are *Metarhizium anisopliae*, which are found all over the world. This species contains an enormous variety of strains and isolates from different hosts and geographical origins. Some of them are Biomet®, Ankush® and Metarhoz-P®.

Protozoan Insecticides:

The majority of unicellular eukaryotes or protozoa are free-living organisms that are found in water and soil. Numerous insect hosts are susceptible to infection by protozoan diseases. Many of these diseases are more significant because of their long-lasting, incapacitating effects, even if they can kill their insect hosts. The majority of the potential for use as insecticides appears to be offered by species in the genera *Vairimorpha* and *Nosema.* The microsporidian pathogen *Nosema locustae* which affects grasshoppers is the only protozoan that is now offered in a licensed insecticidal formulation. Trade names for it are Grasshopper Attack® and NOLO Bait®.

Viral Insecticides:

In insects, viruses fall into six main categories that cause illnesses. They are known as baculoviruses, enteroviruses, iridoviruses, densoviruses, entomopoxviruses, and cytoplasmic polyhedrosis viruses. The viruses that cause entomopathy that have two families of baculoviruses—nucleopolyhedroviruses (NPV) and granuloviruses (GV) - have drawn the greatest attention. Double-stranded DNA viruses called baculoviruses are found in arthropods, primarily insects. Baculoviruses provide a significant threat to specific harmful insects. Only at the larval stage do baculoviruses cause fatality in Lepidoptera, the primary group from which they have been derived.

The viruses that cause armyworms, cabbage loopers, imported cabbageworms, soybean loopers, and alfalfa loopers are among the insects that are being studied for potential use as insecticides. As an example, *Anticarsia gemmatalis* is a significant soybean insect pest in Brazil. Prior to the establishment of an integrated pest management program, the pest was frequently controlled using insecticides and the threat raised by AgMNPV expanded from 2000 hectares to two million hectares of soybean treatment area by 2002 – 2003. AgMNPV control of *A. gemmatalis* in Brazil was a highly effective effort that is regarded as the most significant globally. Currently, the generation of commercial baculoviruses takes place in vivo, where the virus is used in an open field to infect larvae (which are dead) or grown larvae fed food tainted with the baculovirus in a laboratory. Formerly registered by the US EPA, the Heliothis NPV (Elcar®) and the codling moth GV (Decyde®) both generate commercially, but both registration and availability for these goods have expired.

Nematicidal Insecticides:

Nematodes do not behave as microorganisms. Rather, these are roundworms with many cells. However, the nematodes employed in insecticidal products are tiny in size. Nematodes used for pest prevention are known as entomogenous nematodes The most often employed entomopathogenic nematodes in insecticidal preparations are *Steinernema feltiae* (also known as *Neoaplectana carpocapsae*), Scapteriscae, *S. riobrave*, *S. carpocapsae*, and *Heterorhabditis heliothidis*. Trade names for these products include Vector®, Scanmask®, and BioSafe®; other companies only use the nematode's scientific name.

Environmental Effects of Microbial Pesticides:

The research and application of microbial pesticides for pest control is supported by their specificity, biodegradability, and safety for the environment. Certain viruses and bacteria that are selected for commercial development may only infect a single or very few of closely related insect species. Some may have an impact on a relatively wider spectrum of insects and related arthropods, including nematodes and fungus. The commercially available microbial pathogens, however, are unique to their targets and have not been demonstrated to infect plants or animals. The microbial insecticides are biodegradable, so they don't penetrate the food chain or leave any negative environmental consequences.

Entomopathogenic fungus spores are not able to live through high temperatures and are unable to remain on leaves for extended periods of time. On the other hand, diseased cadavers that occur to the ground sporulate in favorable conditions during the winter underground. Only small proportions of these conidia make it through the summer and present themselves in the next rainfall season once the pest population has grown.

Within the class of insect viruses, baculoviruses are considered safe and effective bio-insecticides that are specific to invertebrates. They have been employed all throughout the world to deal with various insect pests, mostly Lepidoptera with the exception of the NPV of the soybean caterpillar.

Microbial Pesticides Effect on Natural Enemies:

In order to effectively manage the target pests, research on the production of microbial pesticides in India has concentrated on identifying virulent isolates. There is very little information available regarding their effects on non-target pests, the environment, and natural enemies. Over the past ten years, research on microbial pesticides has concentrated on producing data regarding their bio-efficacy as well as safety against natural enemies, persistence in the environment, phytotoxicity, etc.

Conclusion

Since most microbial insecticides are only effective against a limited variety of pests and are quickly rendered inactive by the environment, users must accurately identify the target pests and strategically plan the most effective administration. However, these same attributes also indicate that there are no excessive concerns of environmental or human harm when using microbial pesticides. Another important aspect is in produce biological pesticides which are critical to address concerns with faulty formulations or preparation, short shelf lives, lethargic pest control, high market prices, and other issues relevant to marketing registration.

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MIGRATORY BEEKEEPING IN INSECT CONSERVATION

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Introduction

Migratory beekeeping is a contemporary approach to commercial beekeeping that significantly boosts honey production. This method involves moving honey bee colonies from areas with depleted nectar to locations with abundant nectar. This practice not only benefits beekeepers by increasing honey yields but also enhances crop production through improved pollination, offering extra income to farmers. Many plants rely on honey bees for pollination, making migratory beekeeping a valuable practice. In several developed nations, it is regarded as a profitable enterprise and plays a notable role in their economies.

Introduction

Honey bee colonies especially *Apis mellifera* are easily transportable and manageable, making them ideal for pollination both wild and cultivated plants. The use of managed honey bee colonies to pollinate crops is a response to the loss in wild pollinators. Growers utilize managed honey bee colonies to maintain continuous pollination of crops, especially in climate conditions that limit wild pollinator range. To optimize crop pollination, honey bee colonies are placed on the foraging site during flowering (when 20-40% of the flowers are open) in small batches at a specific density per acre. The stocking density varies by crop. Commercial pollination services enter the agricultural process at specific times based on crop flowering cycles. Commercial crop pollination has created a market for colony leasing rates, which vary by crop and year. The market benefits both beekeepers and growers. The grower pays colony leasing fees for pollination and can earn money from honey production if the crop produces valuable nectar. The profitability and sustainability of the sequence to which the forage site belongs are enhanced by pollination. Not only do the colonies produce honey when the foraging site is covered in natural flora, but they also serve as an ecosystem pollinator, contributing to the sustainability of the surrounding ecology by multiplying a variety of untamed and spontaneous plant species (Kukrer *et al*., 2021).

Crops that benefit from migratory beekeeping

Almonds, Apples, Plums, Cherries, Alfalfa, Clovers, Sunflowers, Blueberries, Cranberries, Watermelon, Cantalope, Cucumbers, Pumpkins, Peppers etc. are the crops that get benefited from migratory beekeeping (Kumsa *et al*., 2020).

Useful consideration for migratory beekeeping

Season

In cold and rainy conditions, hives should be covered with a tarpaulin while being transported. In contrast, during summer or monsoon, it was best to move colonies at night when temperatures were cooler. To encourage bees clustering outside to return to the hives, use of few puffs of cool smoke or lightly spray them with water. Make brief stops and temporarily place the apiaries along the route at locations with suitable bee forage for a day (Feketene et al., 2023)

Distance of migration site

In colder months, bees hunker in around the brood nest and eat copious amounts of food storage to generate heat. This allows the hive entrance to be closed and bee transported. In warmer weather, the hive body should be covered with a full-sized traveling screen and the entrance should always be secured with a screen or perforated zinc sheet. In order to relieve the restricted bees, it is beneficial to have one or two stops during the summer for brief, temporary apiary sittings of a day or two in a suitable location with some bee flora. The brood mortality of the colonies was frequently caused by continuous movement for longer than 48 hours.

Preparing and packing the colonies for migration

Gather extra honey a few days before the migration. Every nook and fracture in the hives, whether closed or sealed. It is necessary to replace any excessively damaged hive pieces with fresh ones. The inner cover, bottom board, and hive body should all be secured together with nails or staples. To stop hive components from moving or slipping, use two staples on either side of the junction and slant the staples in different directions. Use metal or nylon traveling belts around the hives as an alternative to the staples; rubber belts were not a good idea because they were elastic and can tolerate hive components slipping.

Type of vehicle

Mini trucks, which were shockproof vehicles, were used to move the colonies. The engine's vibration may also have an impact on the bees, causing them to rise and depart the hive. The full load of bee hives from above may also be constructed with additional features like ventilators close to the floor in order to stop the bees from moving. If a brief pause was required, it was advised that the engine be left running.

Transportation of bee hive

There was no issue if they were transported more than two miles away because that distance was outside of their flying range. We cannot transport them all if they were moved more than two miles away. Every day in the evening, they should be relocated a yard to the side. If this isn't feasible, they should be moved to a location that were at least two or three miles away from both locations that was from the location where the colony was being moved.

Factors influence migratory bee keeping

1. Inference of season of production of honey in different regions.
2. Identification of migratory sites for effective production.
3. Preparation of migratory schedules for different regions of the country.

Conclusion

In extended periods of drought, migratory beekeepers produce more honey and require less feed than stationary beekeeping. Coordination and communication between beekeepers and landowners of possible migratory locations should be the foundation of local initiatives for migratory beekeeping. To ensure the best possible use of the floral resources at hand, *A. mellifera* beekeepers must possess comprehensive knowledge of the availability of various floral sources in close proximity to their apiary, including their seasonal availability and migration schedules.

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PASTEURELLOSIS IN RABBITS

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Introduction

Pasteurellosis in rabbits, often referred to as "Snuffles," is one of the most common and serious bacterial diseases affecting both domestic and commercial rabbit populations. It is caused by the bacterium *Pasteurella multocida*, which can infect various systems in the rabbit's body, including the respiratory tract, skin, and internal organs.

Key Features of Pasteurellosis

- **Causative Agent**: *Pasteurella multocida*, a gram-negative bacterium.
- **Transmission**: Highly contagious, spread through direct contact, aerosols, or contaminated environments.
- **Chronic Nature**: The disease can persist in the rabbit's body, often becoming a chronic, relapsing condition.

Forms of Pasteurellosis in Rabbits

1. **Respiratory Pasteurellosis ("Snuffles")**

- **Most Common Form**: The respiratory form is widely recognized in commercial and pet rabbits.

Symptoms:

- **Nasal Discharge**: Thick, creamy, white to yellow discharge from the nose.
- **Sneezing and Coughing**: Repeated sneezing episodes, often accompanied by noisy or labored breathing.

- **Conjunctivitis**: Eye discharge that may cause crusting around the eyes (leading to "weepy eyes").
- **Rhinitis (Runny Nose)**: Swelling of the nasal passages, making breathing noisy.
- **Head Shaking and Ear Infections**: If the infection spreads to the middle or inner ear, head shaking, scratching at the ears and loss of balance (otitis media or interna) may occur.

Complications: The infection can extend to the lungs, leading to **pneumonia**, which may be life-threatening. In severe cases, the rabbit may stop eating due to respiratory distress.

2. **Abscesses**
   - **Formation**: Pasteurellosis can lead to the development of **abscesses**, which are localized collections of pus.
   - **Common Sites**: Abscesses often form under the skin, around the head, or on the limbs, but they can also affect internal organs such as the liver or kidneys.
   - **Symptoms**:
     - Firm, swollen lumps under the skin.
     - May rupture and drain pus.
     - When located internally, abscesses may cause general lethargy, weight loss, or organ failure.
   - **Treatment**: Surgical removal or drainage, often combined with long-term antibiotics.
3. **Pneumonia**
   - **Symptoms**:
     - Difficulty breathing, lethargy, and high fever.
     - Progressive deterioration in the rabbit's general condition.
     - Cyanosis (bluish tinge) due to lack of oxygen in severe cases.
   - **Prognosis**: Pneumonia is severe and often fatal without aggressive treatment.
4. **Otitis (Ear Infections)**

Symptoms:

- **Head Tilt (Torticollis)**: One of the most visible signs of inner ear infection. The rabbit tilts its head to one side due to balance disturbances.
- **Loss of Balance**: Circling, unsteady gait, or falling over.
- **Ear Discharge**: Infected ears may ooze fluid.

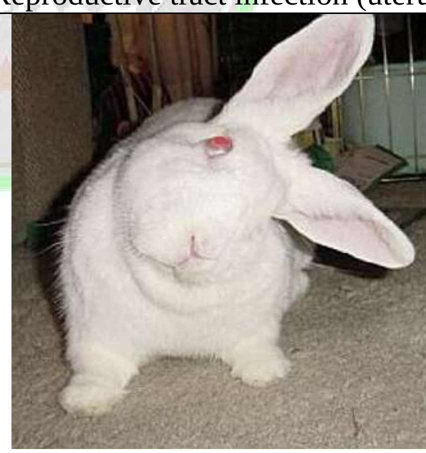
  - **Complications**: The infection can spread from the middle ear to the brain, leading to neurological problems like seizures.

5. **Reproductive Tract Infections**
   - **Symptoms in Does** (Female Rabbits):
     - **Metritis** (infection of the uterus) can cause abnormal vaginal discharge, infertility, or miscarriage.
     - Swelling and infection of the reproductive organs, especially after kindling (giving birth).
   - **Symptoms in Bucks** (Male Rabbits):
     - **Orchitis**: Swollen testicles, pain, and fever.
     - May lead to infertility if left untreated.
6. **Septicemia (Blood Infection)**
   - **Severe Form**: The bacteria can invade the bloodstream, causing **septicemia**, which is fatal in most cases.
   - **Symptoms**:
     - High fever, lethargy, lack of appetite, rapid decline in condition.
     - **Death** often occurs suddenly due to overwhelming infection.

Transmission and Risk Factors

- **Direct Contact**: Healthy rabbits can contract Pasteurellosis through contact with infected animals, especially via nasal secretions, saliva, or pus from abscesses.
- **Aerosol Transmission**: The bacteria can be spread through sneezing, contaminating the air in close quarters.
- **Contaminated Surfaces (Fomites)**: Feeders, water bottles, cages, or caretakers' hands can act as carriers for the bacteria.
- **Stress**: Factors such as poor hygiene, overcrowding, extreme temperatures, transportation, or changes in diet can weaken a rabbit's immune system and make them more susceptible to Pasteurellosis.
- **Asymptomatic Carriers**: Some rabbits may carry the bacteria without showing symptoms, but they can still spread the infection to other rabbits, especially during stressful periods.

Various symptoms of Pasturella infection in Rabbits

	
Conjunctivitis	Rhinitis
	
Abscess formation	Reproductive tract infection (uterus)
	
Otitis	Wry neck

Diagnosis

- **Clinical Examination**: Veterinarians often suspect Pasteurellosis based on clinical signs such as nasal discharge, sneezing, and eye infections.

- **Bacterial Culture**: Samples of nasal discharge, abscess fluid, or blood can be cultured in a lab to identify *Pasteurella multocida*.
- **X-rays**: In cases of pneumonia or otitis, X-rays may help assess the extent of lung or middle ear involvement.
- **Serology**: Blood tests can be used to detect antibodies against *Pasteurella*, though they are less commonly used in practice.

Treatment

1. **Antibiotics**:
   - Common antibiotics used include **enrofloxacin**, **tetracyclines**, **ciprofloxacin**, and **penicillin** (in abscess cases).
   - The choice of antibiotic depends on the severity of the infection, and long-term treatment may be necessary since *Pasteurella* can be persistent.
   - In some cases, antibiotics can reduce symptoms but may not completely eliminate the bacteria, leading to chronic, recurrent infections.
2. **Supportive Care**:
   - Ensure proper hydration and nutrition. Rabbits with respiratory distress may need nebulization therapy (humidified air mixed with antibiotics or bronchodilators).
   - Good cage hygiene and proper ventilation are essential to reduce the risk of re-infection.
3. **Surgery**:
   - Abscesses may need to be surgically drained or removed, and some internal abscesses require advanced medical intervention.
   - Otitis and other complications may require more invasive treatments if they don't respond to antibiotics.

Prevention

1. **Isolation of Infected Rabbits**: Infected rabbits should be separated from healthy ones to prevent the spread of the disease.
2. **Biosecurity Measures**:
   - Disinfect cages, water bottles, and feeders regularly.
   - Use separate equipment for sick and healthy rabbits.

3. **Reduce Stress**: Minimize stressful conditions in the rabbitry, such as overcrowding or extreme temperatures, as stress can weaken the immune system and increase susceptibility to infections.
4. **Quarantine New Animals**: Newly acquired rabbits should be quarantined for at least two weeks before being introduced into the main herd.
5. **Vaccination**: Some countries have vaccines for Pasteurellosis, but they may not be universally available.
6. **Good Ventilation**: Proper airflow reduces respiratory problems and lowers the risk of airborne transmission.

Prognosis and Impact on Rabbit Farming

- **Chronic Disease**: Even with treatment, Pasteurellosis can become a chronic issue in rabbits, leading to recurrent symptoms and outbreaks.
- **Economic Impact**: In commercial rabbit farms, Pasteurellosis can lead to significant economic losses due to mortality, reduced productivity, and the costs of medical treatment and preventive measures.
- **Culling**: In severe cases, especially in large-scale operations, culling infected animals may be necessary to control the spread of the disease.

Conclusion

Pasteurellosis in rabbits is a highly contagious, often chronic bacterial infection that poses serious health and management challenges in both pet and commercial rabbit populations. Effective prevention, early diagnosis, and appropriate treatment are key to minimizing its impact. Pasteurellosis can become a chronic issue in a rabbitry, so ongoing management and preventive strategies are key to minimizing its impact on commercial rabbit farming.

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NEURAL NETWORKS- APPLICATION IN AGRICULTURE

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Introduction

Computers are a prime component of this whole revolution. Computers that can help fight diseases by designing new drugs, computers that can design better computers, computers that simulate reality and what not! This is a very exciting time for technology as the traditional boundaries are now becoming blurred. We often tend to think that computers can only decide on whether a statement is true or false. Such logical statements are then linked together to form a series of rules. To program a computer, all that is needed is to precisely define the problem, write a specification and use these rules. The program tells the computer rule by rule, exactly what to do. But it is difficult to program a computer for more subjective tasks, like predicting what the weather is going to be, or what the price of gold will be tomorrow. These tasks are in fact impossible to define accurately. Patterns need to be recognised that are complex and imperfect. Nature is chaotic and we need something to decode this chaos.

A different approach is needed to give computers more 'human-like' abilities, capability to make judgements, guesses and to change opinions. We humans learn by example and do not need to see every example to make a guess, a judgement based upon what we have been taught. With the growing emphasis on autonomy, intelligence and an increased amount of information required by businesses, traditional processing technology can only cope through faster hardware with more complex bespoke software. With this approach, some of the questions raised are

(1) How long is it going to write this software

(2) How many different versions for each variation are required?

(3) Having been written, how safe is it from bugs?

The problem growing throughout the 1990s and into the millennium is that engineers no longer have the luxury in development to calculate all the algorithms or identify all the rules in these complex systems. In fact, most of these systems are so chaotic that doing so would be futile and prone to failure. Given the high stakes and intense competition within all areas of industry, intelligent business decisions are more important than ever. Even more important is the case for military applications. Data analysis plays an important role as a critical strategic weapon in business and operations of the armed forces (both peace-time and war-time).

2. NEURAL COMPUTING?

The rapid pace of change and a climate of competitiveness, in which the profoundly and speedily informed gain the advantage and demand a more incisive consideration and induction of emerging IT than has hitherto been the case. There are a range of Al technologies available now-each with its own strengths and weaknesses. These are:

(1)Expert systems (2) Fuzzy logic (3) Case-based reasoning (4) Neural networks
(5) Genetic algorithms

3. NEURAL NETWORKS

Neural computers are based on the biological processes of the brain (human neural systems). Terms like can learn brain-like, massively parallel, learning machines and revolutionary have been used to describe neural computing. And these are true! It is not surprising that most industries believe that taking a neural approach will require special, expensive neural integrated circuits, big parallel computers, or very high powered computers.

This is not true!

Conventional computers concentrate on emulating human thought processes, rather than actually how they are achieved by the human brain. Neural computers, however, take an alternative approach in that they directly model the biological structure of the human brain and the way it processes information (although at a much simpler level). This necessitates a new kind of architecture, which, like the human brain, consists of a large number of heavily interconnected processing elements operating in parallel manner. Such architecture is now both technically and commercially feasible to be deployed on a standard computer (from the laptop and desktop to the mainframe) and is certain to increase in general usage.

Neural computing is a relatively new but rapidly expanding branch of computing whose origin dates back to the early 1940s. Though it has been largely overshadowed since the 1960s by conventional computing, it has experienced an upsurge in popularity in the late 1980s as a result of new developments in the field and general advances in computer hardware technology. Neural networks are mathematical models, originally inspired by biological processes in the human brain.

3.1 Basic Theory:-

In this Section, neural networks are considered from an analytical viewpoint, so as to dispel any notions that neural networks are 'magical devices'. In fact, a neural network is little more than an example of fairly specialised parallel processing architecture. A point which should be noted is that neural computing is not to be viewed as a competitor to conventional computing, but rather as a complementary technique. The most successful neural computing applications to date have been those which operate in conjunction with other computing techniques. For example, using a neural network to perform a first pass over a set

of incoming data, then passing the results over to a conventional system for subsequent processing.

3.2 What is a Neural Network?

Neural networks can be taught to perform complex tasks and do not require programming as conventional computers. They are massively parallel, extremely fast and intrinsically fault-tolerant. They learn from experience, generalise from examples, and are able to extract essential characteristics from noisy data. They require significantly less development time and can respond to situations unspecified or not previously envisaged. They are ideally suited to real-world applications and can provide solutions to a hos' of currently impossible or commercially impractical problems. In simple terms, a neural network is made up of a number of processing elements called neurons, whose interconnections are called synapses. Each neuron accepts inputs from either external world or from the outputs of other neurons. Output signals from all neurons eventually propagate their effect across the entire network to the final layer where the results can be output to the real world. The synapses have a processing value or weight, which is learnt during training of the network. The functionality and power of the network primarily depends on the number of neurons in the network, the interconnectivity patterns or topology, and the value of the weights assigned to each synapse.

Global interconnectivity means that all the neuron outputs of one layer connect (through their weights) to every neuron input in the next layer and only to these neurons. The inputs to the neurons on the input layer are from the external world. Such networks perform classification and optimisation operations very well. The neuron output values can be expressed mathematically, but due to the built-in non-linear operators, these equations provide little in the way of an intuitive feel for how neural networks perform their tasks.

There are some additional features for this type of network which generally apply to all neural networks, regardless of architecture. Firstly, a neural network tends to be over-specified, meaning that there are many more unknowns than equations describing the system. Secondly, usually there are many weight sets (perhaps an infinite number) that will solve the same problem. Lastly, the weight sets are generated from training algorithms and are not programmed like conventional algorithms. This training process relieves the designer of developing an algorithmic solution for the problem at hand.

Some ANNs are classified as feed-forward while others are recurrent (i.e., implement feedback) depending on how data is processed through the network. Another way of classifying ANN types is by their method of learning (or training), as some ANNs employ supervised training while others are referred to as unsupervised or self-organising. Supervised training is analogous to a student guided by an instructor. Unsupervised algorithms essential perform clustering of data into similar groups, based on the measured attributes or features servlng as Inputs to the algor~thms. This is networks (ANNs). analogoust o a student who derives lesson totally on his or her own. ANNs can be implemented in software or in specialised hardware.

4. ADVANTAGES OF NEURAL NETWORKS

As seen already, neural computers have the ability to learn from experience, to improve their performance and to adapt their behaviour to new and changing environment. Unlike conventional rule-based systems, neural networks are not programmed to perform a particular task using rules. Instead, they are trained on historical data, using a learning algorithm. The learning algorithm changes the functionality of the network to suit the problem by modifying the values of the connection weights between processing elements. Once trained, the network interprets new data in a way that is consistent with the experience gathered during training. Neural networks can provide highly accurate and robust solutions for complex non-linear tasks, such as fraud detection, business lapse/churn analysis, risk analysis and data-mining. One of their main benefits is that the method for performing a task need not be known in advance; instead it is automatically inferred from the data. Once learned, the method can be quickly and easily adjusted to track changes in the business environment.

A further advantage of neural networks over conventional rule-based systems and fuzzy systems is that, once trained, they are far more efficient in their storage requirements and operation; a single mathematical function can replace a large number of rules. An added benefit of this more compact mathematical representation is that it introduces a natural form of regularisation or generalisation. This makes neural systems extremely robust to noisy, imprecise or incomplete data.

5. APPLICATIONS OF NEURAL NETWORKS

Artificial neural networks have become an accepted information analysis technology in a variety of disciplines. This has resulted in a variety of commercial applications (in both products and services) of neural network technology (The applications that neural networks have been put to and the potential possibilities that exist in a variety of civil and military sectors are tremendous.) Given below are domains of commercial applications of neural network technology.

* **Business**

1. Marketing

2. Real Estate

* **Document** & **Form Processing**

1. Machine printed character recognition

2. Graphics recognition

3. Hand printed character recognition

4. Cursive handwritten character recognition

* **Finance Industry**

1. Market trading

2. Fraud detection

3. Credit rating

* **Food industry**

1. Odour/aroma analysis

2. Product development

3. Quality assurance

* **Energy Industry**

1. Electrical load forecasting

2. Hydroelectric dam operation

3. Natural gas

* **Manufacturing**

(1)Process control

(2) Quality control

* **Medical** & **Health Care Industry**

1. Image analysis

2. Drug development

3 Resource allocations

* **Science** & **Engineering**

1. Chemical engineering

2. Electrical engineering

3. Weather forecasting

7. NEURAL NETWORKS- INDIAN SCENARIO

Lot of opportunities exist in the country for Al technologies, especially neural computing applications. Though most of the work is being done around robotics and expert systems, there are also people and organisations capable of developing neural system products? The potential sectors of application range from manufacturing, banking and finance, defence, telecommunications, pharmaceuticals to holiday industry.

Substantial amount of work is being done at the Centre for Artificial Intelligence and Robotics (CAIR, Bangalore) and the Institute for Robotics and Intelligent Systems (IRIS, Bangalore). They have developed a neural network for optical character recognition. The project is complete and awaits commercialisation. IRIS is working on functional electrical simulation using neural networks to simulate the muscles of a handicapped person and allow him to walk.

Scientists at the Indian Statistical institute (Machine Intelligence Unit), Calcutta, have figured out computer simulated models, more advanced than human brain, for creating artificial entities more intelligent than present day systems in performing cognitive tasks. This project will have far reaching implications on medical research and robotics.

Neural computers perform very favourably in business and military applications. They do not require explicit programming by an expert and are robust to noisy, imprecise or incomplete data. Furthermore, knowledge is encapsulated in a compact, efficient way that can easily be adapted to changes in business environment. As with all technologies, there is a window of opportunity for exploitation-and that window is here today. You cannot afford to ignore the fact that your competitors are already investigating the opportunities and realising the significant business benefits that neural technology brings to a range of applications. The reason one should use neural computing technology is the competition!

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CHATGPT AND A NEW ACADEMIC REALITY

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Introduction

A Brief Introduction to Underlying AI Concepts Artificial intelligence, machine learning, and natural language processing are rapidly advancing fields that are having a significant impact on a wide range of industries and applications (Wamba et al., 2021). Chatbots, which are computer programs designed to mimic human conversation, are one example of the practical uses of these technologies (Adamopoulou & Moussiades, 2020a). The following paragraphs provide a brief overview of artificial intelligence, machine learning, and natural language processing –as well as the ways in which chatbots are utilizing these technologies to interact with users in a more human-like manner – in order to ensure that all readers have a basically familiarity with the technology and concepts that underpin large language models like the Generative Pretrained Transformer and ChatGPT. Artificial intelligence (AI) is a multidisciplinary and interdisciplinary field that has grown tremendously since the introduction of manually operated computers in the 1950s (Haenlein & Kaplan, 2019). It has the potential to revolutionize various industries, and is defined as any theory, method, or approach that assists machines, particularly computers, in analyzing, simulating, exploiting, and exploring human thought processes and behaviors (Lu, 2019).

Artificial intelligence (AI)

AI involves the simulation of intelligent behavior in machines, with the goal of creating machines that can mimic human intellect in important ways such as language comprehension, reasoning, and problem-solving (Chowdhary, 2020). Self-learning is a key component of AI, allowing systems to acquire new information and improve their knowledge-based judgments and conclusions through experience and data (Mintz & Brodie, 2019). Machine learning and deep learning techniques have become the standard approach to advancing AI, with artificial neural networks (ANNs) allowing robots to learn and reason like humans and perform increasingly complex tasks (Lu, 2019). AI has already had a significant impact on various industries such as pharmaceutical, industrial, financial, medical, and managerial, and is expected to play a crucial role in helping businesses of all sizes stay competitive in the global economy (Makridakis, 2017). AI encompasses a range of specialized domains including machine learning (ML) and natural language processing (NLP). The volume of data being generated from various sources, including people, devices, and computers, continues to grow at an exponential rate (Beath et al., 2012). As the amount of data becomes too large for individuals to make sense of and draw meaningful insights from, it becomes necessary to automate systems that can learn from the data to provide valuable insights. This is where machine learning (ML) comes in. ML is a key component of artificial intelligence (AI) and involves the development of computational theories for learning processes that allow machines to learn from experience without being explicitly programmed to do so (Chowdhary, 2020; Mahesh, 2020).

Natural language processing (NLP)

It is at the intersection of computer science and statistics and is used to create programs that can automatically learn from data, acquire knowledge from experience, and continuously improve their learning behavior to make predictions based on new data (Jordan & Mitchell, 2015). ML is a useful technique in various areas of AI, including computer vision, voice recognition, and natural language processing (NLP). In this paper, we focus on ChatGPT, an AI technology that uses NLP to enable computers to engage in natural language conversations (Radford et al., 2018). ML is an essential part of ChatGPT, as it allows the system to learn from data and improve its language processing abilities over time, leading to more effective communication and interaction between humans and computers. Artificial intelligence (AI) has become a part of everyday life with the advancement of processing power and the use of intelligent agents (Adamopoulou & Moussiades, 2020b).

Intelligent agents

Intelligent agents are programs that can act independently and make decisions based on their observations of the environment, human input, and internal knowledge. Chatbots, also known as conversational artificial intelligence bots, are a type of intelligent agent that can respond to conversations through text or voice as if they were sentient beings, and they have gained popularity due to their usefulness in various applications such as customer service, healthcare, education, and personal support (Brandtzaeg & Følstad, 2017; Nagarhalli et al., 2020). Chatbots have been developed using natural language processing (NLP) techniques, which allow them to understand and interpret human language input (Khanna et al., 2015). In recent years, chatbots have become more popular, particularly among younger generations who prefer instant, one-onone communication through short messages (Lokman & Ameedeen, 2018). This paper focuses on ChatGPT, a chatbot that uses NLP and AI to generate natural language conversations, and specifically on how it can be used in academia to create and write research and scholarly articles, and the ethical issues associated with this development. Introducing ChatGPT OpenAI is a research laboratory that has made significant contributions to the field of artificial intelligence, including the development of the highly advanced language model, GPT-3. In addition to GPT-3, OpenAI has also released ChatGPT, a chatbot that uses natural language processing to generate responses to user inputs. Both GPT-3 and ChatGPT have garnered significant attention and have the potential to revolutionize a wide range of language-related tasks. In this section, we will delve into the details of OpenAI, GPT-3, and ChatGPT, exploring their capabilities, limitations, and potential applications.

ChatGPT

ChatGPT is a public tool developed by Open AI that is based on the GPT technology (Kirmani, 2022). Essentially, it is a highly sophisticated chatbot that can fulfill almost any text-based request (Liu et al., 2021). However, ChatGPT is capable of much more than just answering simple questions. It can also fulfill more advanced requests, leveraging its extensive data stores and efficient design. For example, if you are unsure of what to write in a thank you card to a coworker, you can simply ask ChatGPT to write one for you, and it will quickly generate a wellwritten, multi-paragraph letter. ChatGPT can even help with more challenging tasks, such as composing a note to address a coworker's lack of productivity. It is only a small leap (and in the "mind" of ChatGPT, no leap at all) to ask GPT to write "an essay on the value of artificial intelligence." In less than one minute, GPT can compose an essay of hundreds of words, written at professional researcher quality. An article could easily be written entirely by GPT by breaking the main topic into subtopics and then having GPT write each section. If the capacity of GPT is truly harnessed (through a full version that would allow for responses of several thousand words instead of just several hundred words), then an entire paper could be written in minutes with very minimal prompting from a researcher. This innovation could cut the time for composing research essays from several dozen hours to a couple dozen seconds, or even render the professional author/researcher obsolete.

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WOLBACHIA & ITS UTILITY IN SERICULTURE

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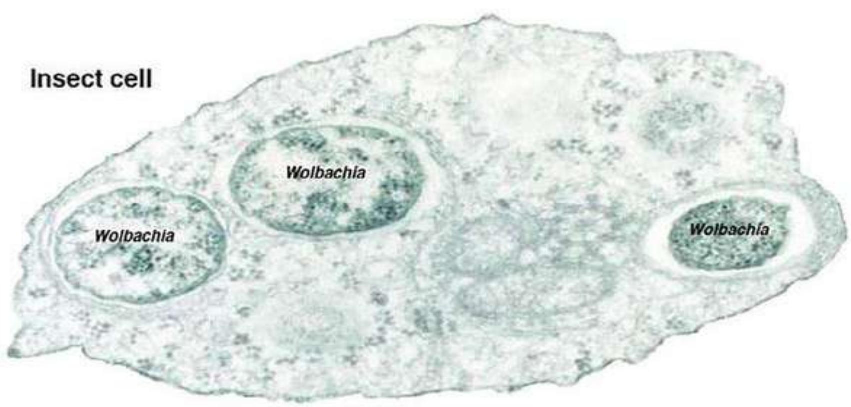
Introduction

Wolbachia are maternally inherited gram negative bacteria which becomes a potential endosymbiotic microbial biocontrol agent. It belongs to order Rickettsia and is reported in the cytoplasm of various insects and terrestrial nematodes. *Wolbachia* gained much attention and extensively used against various pest and vector management through manipulating the targeted reproductive system, interference with nutritive and metabolic pathways, distortions the biology of host by various infectious phenotypes like incompatibility of cytoplasm (CI), killing of male embryos, parthenogenesis and feminization (developing the female characters into male). These autonomous infectious mechanisms support reproductive phenomenon of the infectious organism and allow the *Wolbachia* to increase their infection.



W. pipientis is more prominent and effective transmitter of intracellular symbiotic infections which known to infect more than 2/3 of global insect communities ranging from 20 -

76%. Moreover, some species of class insecta (lice, Anoplura: Mallophaga) had 100% *Wolbachia* infections.

Wolbachia is maternally inheritable symbionts, i.e. vertically transfer from egg cytoplasm to offsprings and could also cause infection through horizontal transfer from infected uninfected species. *Wolbachia* can also be cultured outside the cells that have great potential to transfer infection and live outside the host cell (culture cell) over a reasonable period of time

It has also great potential to control the population of insect's pests as a microbial natural enemy with multiple ways of infectious phenotypes to manipulate host biology of targeted populations. Due to its ubiquitous behaviors, evolutionary, biologically and ecologically it has become a key potential intracellular biocontrol agent in pest biocontrol strategies.

Taxonomic characteristics of the *Wolbachia*

Wolbachia species are members of the obligate intracellular Rickettsiales and forge as a dual competitive microbial agent (DCMA) like parasitic relationships with numbers of arthropods and mutualistic relationships with various insect orders, particularly with nematodes.

Scientific classification	
Domain:	Bacteria
Phylum:	Proteobacteria
Class:	Alphaproteobacteria
Subclass:	Rickettsidae
Order:	Rickettsiales
Family:	Rickettsiaceae
Genus:	***Wolbachia***

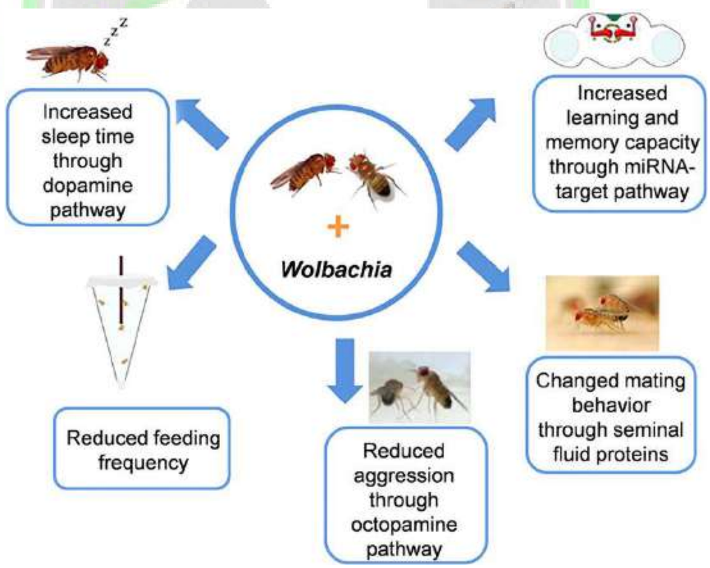
Identification and detection of *Wolbachia*

Wolbachia is completely dependent on the cytoplasmic atmosphere of the host. The average size of these bacteria is ranging from **0.8 to 1.5 µm** and covers by at least 2 cell membranes. Although these bacteria have been identified as maternally inherited infection through infected mother to offspring but the infections of *Wolbachia* is not only limited to reproductive systems of the host but it also infect and colonized in various tissues such as **muscle**

cell, digestive organs, brain, fat body and haemolymph of the host. Infection of *Wolbachia* can be confirmed within the tissues of various invertebrates by using various identification techniques such as visualized Giemsa stain , fluorescent dye DAPI, fluorescent cells nucleic acids dye SYTO 11 techniques . Furthermore, in situ hybridization with specific *Wolbachia* DNA probes and staining of immune through antibodies is also used for the diagnosing the *Wolbachia* infection inside the host tissues. A very sensitive PCR (Polymerase chain reaction) technique along with other tools like Hybridization of DNA and analysis of sequence are also extensively used for *Wolbachia* detection.

Wolbachia-host association

The endosymbiont *Wolbachia* manipulate and alter the host reproductive systems through various phenotypic mechanisms such as the **killing of male sperm, feminization, cytoplasmic incompatibility and parthenogenesis**. All phenotypes are focus on the enhancing the progenies of infected female of associated host population and therefore, may cause the reason to increase the transmission and availability of bacteria within the hosts. These effects may be beneficial or detrimental and are confounded by genetic and environmental factors.



1. Killing of male embryos

Wolbachia is maternally-inherited bacteria that **kill males during embryonic development** and significantly reduced the populations of males. Hence, infected females may lay a mixed brood of male and female eggs, but only female eggs survive to become adults. A broad range of endosymbionts like *Flavobacteria, Rickettsia, Arsenophonus, Wolbachia,* and

Spiroplasma are associated with the host and responsible for induction of male killing but cytological mechanisms causing male-killing are still unknown. Killing of a male reported in class Insecta including Lepidoptera, Diptera and Coleoptera .

2. Feminization

Feminizing strains of *Wolbachia* make **changes in genetic of male hosts** and force it to develop into functional female which is known as alteration of sex or feminization. Such infections are common in terrestrial isopods especially in woodlouse. Sex in these crustaceans is determined by the action of a male hormone that suppresses female development. *Wolbachia* is thought to inhibit development of the androgenic gland that produces this hormone and also may block receptor sites required for hormone activity. Advantageous mechanisms of *Wolbachia* in which double offspring of the female which eventually increase the rate of infections.

3. Cytoplasmic incompatibility

Cytoplasmic incompatibility (CI) is the most abundant *Wolbachia* induced phenomena that **alter the host reproduction**. The presence of CI in *Wolbachia* have been reported in wide range of insects includes flour beetles, alfalfa weevils, wasps, plant hoppers, fruit flies, flour moths, wood louse, mites and numerous mosquitoes species.

CI may occurred by matting's between *Wolbachia* infected males and uninfected females. CI occurs in two directions

- When *Wolbachia* infected male cross with uninfected female causing unidirectional CI.
- Secondly when both male and female carry opposite strains which are contrastive to each other known as bidirectional CI. These types of CI caused higher embryonic death and organism produced less number of progenies.

The occurrence of *Wolbachia* in male sperm and found that it introduces a factor here that prevents embryogenesis in the fertilized egg, unless the female partner is infected with the same *Wolbachia* strain to allow the sperm's '**rescue**'.

Unidirectional CI is most frequent and usually occurs between males infected with a single strain or female without any strain of *Wolbachia*. While the bidirectional CI occured only in the condition when both partners are infected with the same *Wolbachia* strains.

4. Induction of parthenogenesis

Wolbachia also associated with parthenogenesis induction (PI) in different host species. Offspring's of these insects have three different types of sex determination i.e. diploid male and female (diplodiploidy); haploid male and diploid female (haplodiploidy); diploid female without a male (thelytoky).

Wolbachia increases the targeted infected female offspring by second type (haplodiploid) of sex determination in various insect species. PI bacteria are found in both A and B divisions of *Wolbachia*, and phylogenetic evidence suggests that PI has evolved several times independently in these bacteria. It therefore appears that PI can evolve easily in the *Wolbachia*.

Parasitic role of *Wolbachia*

Wolbachia (Rickettsiales: Rickettsiaceae) are one of most active maternally inherited endosymbiotic proteobacteria that inhabit wide range of arthropods and nematodes to **manipulate their reproductive systems.**

Parasitic behaviour of intercellular bacteria with invertebrates are very common and play an important role to **manipulate host biological interactions such as reproductions, developments, gene expression** and **immune systems**.

The insect- bacteria association particularly *Wolbachia* exerts negative impacts to reduce host fitness, responsible for degradation and early death, responsible for pathogen dissemination, reduce host survival rate, manipulate reproductive system and inhibit the pathogenicity of host. With these above reproductive manipulations, the bacterium (*Wolbachia*) thrives in its various hosts at the expense of the hosts' reproduction and act like reproductive parasite to reduced host populations successfully.

Mutualistic role of *Wolbachia*

Endo-symbiotic microorganism, particularly *Wolbachia* is not only played an important role in manipulating of host reproduction but also provide protection against targeted host pathogens.

It is beneficial for the host species by increasing the survival rate of host or insect species or enhancing the fecundity rate. In *Tribolium confusum* (Coleoptera: Tenebrionidae) infected male sperm with *Wolbachia* takes long reproductive time than compared to uninfected ones. Infection may also result to protect the host by suppressing the harmful genes (*Drosophila melanogaster*).

Moreover in *Tetranychus urticae*, *Wolbachia* also causes interference in the metabolism of iron which decreases oxidative stress and reduces the death of cells, eventually, enhance the chance of reproduction within the host.

Another mutualistic example of *Wolbachia* is in wasp, *Asobara tabida*, it is very essential for embryogenesis, it also play a hypothesised role in ferritin expression, in fruits flies, *D. melanogaster, D. simulans* it caused resistance against viral RNA infection, in mosquitoes, *Aedes aegpti* it activate the immune systems against numerous pathogens and are also responsible for the micro RNAs expressions.

Utility in Sericulture

The Uzi fly, *Exorista sorbillans* a tachinid endo-larval parasitoid of silkworm, *Bombyx mori* causes severe loss to the farming community of India. The management of the fly pest by using *Wolbachia* endobacteria.

Wolbachia induced reproductive manipulation in Uzi fly, *Exorista sorbillans*, which manipulates reproduction differentially. The most important one is unidirectional cytoplasmic incompatibility between infected males and uninfected females, and bi-directional cytoplasmic incompatibility among natural populations experienced with varied climatic conditions and crosses among different age group flies.

Wolbachia infected Uzi fly display mutualism, where the Uzi fly provides shelter and other requirements for survival and transmission of *Wolbachia* while the Wolbachia enhances the reproductive fitness and survival of Uzi fly.

The presence of two super clade *Wolbachia* in Uzi fly induces expression and evolution of different levels of cytoplasmic incompatibility. This is mainly due to the expression of different levels of modification and rescue factors (mod/resc) in males and females respectively by *Wolbachia*, which is specific for specific *Wolbachia* strains that **increases the interaction highly complex**.

Fecundity enhancement in infected females up to 17–26%. This may be due to increase their transmission via increased offspring production.

Oogenesis showed that it has effect on oocyte metabolism, such as, oocyte production, oocyte differentiation and development and showed that antibiotically cured individuals have stunted growth of ovarian tubule.

The uninfected females display sex ratio distortion of 2:1 male-female ratio.

A method has been developed to curtile the Uzi fly menace on silkworm by administering *Wolbachia* targeted tetracycline via its silkworm hosts diet. The tetracycline by affecting the intestinal microbial flora, not only influenced the larval growth of the silkworm by decreasing larval duration almost a day, increasing silk production and fecundity with normal hatchability besides it decreases the reproductive fitness of the Uzi fly endoparasite by killing or altering the *Wolbachia* density. Using *Wolbachia* for Uzi fly management in silkworm rearing environment to enhance the silk production in India where sericulture employing six million farming folks. Therefore, the Wolbachia is a friend for Uzi fly in natural conditions and also an enemy in an adverse condition.

Administration of **0.05 mg/ml oxytetracycline to the adult Uzi flies** removed *Wolbachia* endosymbionts and resulted in different reproductive disorders, such as

i) reduction in fecundity of uninfected females,
ii) cytoplasmic incompatibility in crosses between infected males and uninfected females,
iii) sterility in the crosses between both males and females from uninfected populations, and
iv) sex-ratio distortion in uninfected females irrespective of the presence of *Wolbachia* in males.

However, tetracycline treatment did not have much effect on longevity of the uzifly. These results suggest that the interaction of *Wolbachia* with its uzifly host is one of mutual symbiosis as it controls the reproductive physiology of its hosts.

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THE IMPACTS OF HEAVY METALS ON CORAL REEFS

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Abstract

Coral reefs are critical marine ecosystems that support biodiversity, protect coastlines, and contribute to global fisheries and carbon sequestration. However, these ecosystems are increasingly threatened by human-induced pollution, particularly heavy metals such as lead, mercury, and cadmium. These toxic substances, originating from industrial runoff, agricultural waste, and oil spills, persist in coastal waters and accumulate in marine organisms, including corals. The effects of heavy metal pollution are devastating, leading to inhibited coral growth, reproductive failure, increased bleaching, and heightened mortality rates among reef-associated species. In addition, heavy metals disrupt coral physiology at a cellular level, weakening immune systems and causing long-term genetic damage. The persistence and bioaccumulation of these pollutants not only harm coral health but also pose risks to humans who rely on seafood from these ecosystems. Addressing heavy metal contamination requires comprehensive mitigation efforts, including stricter regulations, improved wastewater treatment, sustainable coastal development, community engagement, and targeted research to restore and protect these fragile ecosystems.

Keywords: Corals, heavy metals, bioaccumulation, reef biodiversity, mitigation strategies.

Introduction

Coral reefs, often referred to as the "rainforests of the sea," are vital ecosystems that support a vast array of marine life. Found in tropical, shallow coastal waters, they play a crucial role in protecting shorelines, supporting fisheries, and fostering biodiversity. However, these delicate ecosystems face growing threats, not only from climate change but also from human-induced pollution, particularly from heavy metals. Coral reefs are some of the most vital marine ecosystems in terms of biomass production, biodiversity, and carbon sequestration. However, they are highly susceptible to the effects of climate change (Wernberg *et al*., 2013), which is directly related to the accumulation of heavy metals. Heavy metals like lead, mercury, and cadmium, though naturally occurring, have become increasingly abundant in coastal waters due to industrial runoff, agricultural waste, and oil spills. Once introduced into the marine environment, these metals persist for long periods and accumulate in living organisms, including corals. The effects on coral reefs are devastating, ranging from reduced reproductive success to inhibited coral growth, increased bleaching, and higher mortality rates among both coral species and the marine life that depends on them.

The two primary problems associated with heavy metals are their persistence and bioaccumulation. Thus, toxic metals pose a long-term health concern to the general populace as well as to coral reef ecosystems, especially for populations whose primary source of protein is fish and other invertebrates. While some naturally occurring ecosystems do include heavy metals, human action is mostly responsible for the majority of metals found in nearshore oceans. Some of these man-made heavy metals are present in marine environments, such as in drilling fluid used in offshore oil production and accidental oil spills from petroleum tankers, even though the majority of them originate on land. The problem with heavy metals is twofold: they not only threaten the health of coral reefs but also pose long-term risks to human populations that rely on seafood for protein. As the levels of these toxic substances rise in marine food chains, their harmful effects ripple through entire ecosystems, highlighting the need for urgent and effective conservation measures.

Sources of Heavy Metals in Coral Reef Ecosystems:

Heavy metals make their way into coral reef ecosystems primarily through human activities. Industrial discharges from factories, mining operations, agricultural runoff containing fertilizers and pesticides, and improper waste disposal all release heavy metals into nearby coastal waters. Coastal development projects, such as construction and dredging, as well as increased boating and maritime traffic, further contribute to this contamination. Once in the water, heavy metals like lead, mercury, and cadmium are not easily broken down. Instead, they persist in the marine environment for decades, settling in sediments and being absorbed by corals and other marine organisms. Over time, these metals accumulate in coral tissues, disrupting their physiological functions, reducing growth rates, and contributing to the overall decline of reef health. The long-lasting presence of these contaminants makes them particularly dangerous, not only to coral reefs but also to the broader marine food web.

Effect of heavy metals on Coral health:

Heavy metals are harmful to coral reefs, affecting their health in multiple ways. Once these toxic substances enter the reef environment, they disrupt essential biological processes, leading to serious consequences for coral populations.

1. **Inhibited Growth and Reproduction:**

   Heavy metals like copper, lead, and cadmium interfere with corals' ability to grow and reproduce. These metals can disrupt cellular functions, impairing the development of coral larvae and reducing the chances of new coral colonies settling and thriving. Since successful reproduction is critical for reef regeneration, the presence of heavy metals can slow down or even halt the natural recovery of coral ecosystems.

2. **Coral Bleaching:**

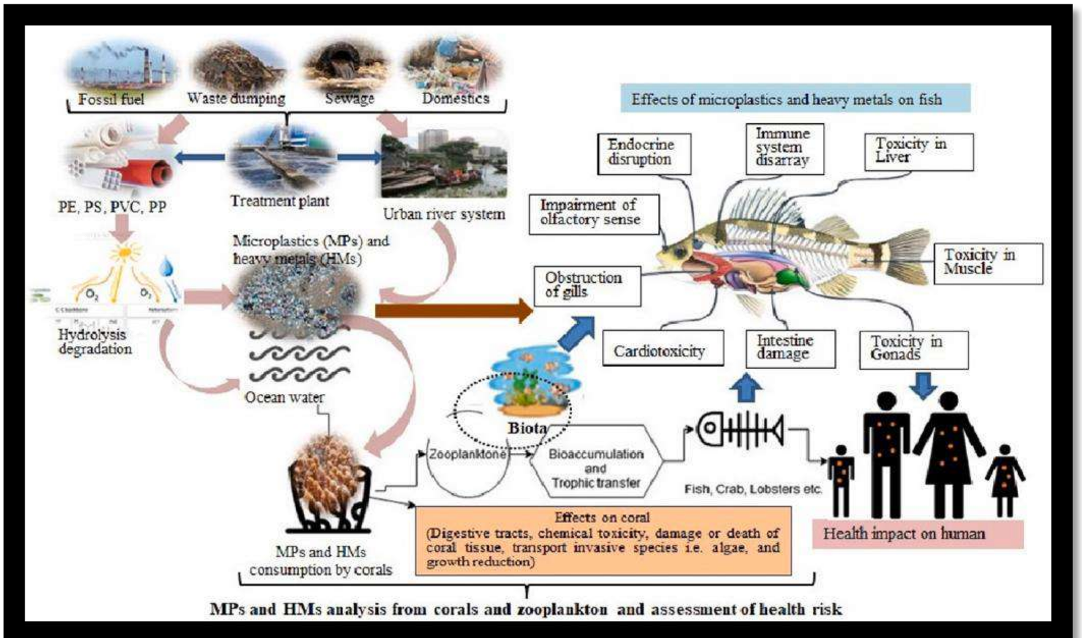
   Coral bleaching is one of the most visible signs of stress in coral reefs, and heavy metal pollution is a known trigger. When corals are exposed to high concentrations of metals, they often expel the symbiotic algae (zooxanthellae) that live within their tissues. These algae are responsible for the corals' vibrant colors and, more importantly, provide them with most of their energy through photosynthesis. Without these algae, corals not only lose their color but also their primary food source, leaving them weak, vulnerable to disease, and at risk of dying.

3. **Weakened Immune Systems:**

   Exposure to heavy metals compromises corals' immune systems, making them more susceptible to infections and diseases. Conditions such as black band disease and white syndrome can spread more easily in weakened corals, further contributing to the decline of already stressed reef ecosystems. Once these diseases take hold, the health of the entire reef can deteriorate rapidly.

4. **DNA Damage and Cellular Toxicity:**

   Heavy metals destroy corals at the cellular level in addition to their apparent effects. These toxic substances can lead to DNA damage and cellular toxicity, causing long-term genetic changes that reduce the overall health and resilience of coral populations. This cellular damage makes it harder for corals to recover from other environmental stresses, such as rising sea temperatures or ocean acidification.



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Impacts on Reef Biodiversity and Ecosystem Function:

Coral reef ecosystems, renowned for their complexity and productivity, are vital to marine biodiversity and provide essential services to humans. However, around 20% of global coral reefs are currently threatened by exposure to toxic substances, including heavy metals. Elevated levels of heavy metals induce several harmful effects on coral health. These include physiological stress, where metal toxicity disrupts coral metabolism, and reproductive impairment (Reichelt-Brushett and Michalek-Wagner, 2005)**;** it reduces fertilization rates, reproductive success, and the survival of coral larvae (Reichelt-Brushett and Harrison, 2000). Heavy metals also alter the population and growth of zooxanthellae, the endosymbiotic algae crucial for coral nutrition. This disruption negatively impacts photosynthesis, leading to decreased coral calcification and growth, especially during the juvenile polyp stage. Additionally, heavy metals are linked to an increase in coral bleaching, making reefs more susceptible to environmental changes, and cause higher mortality rates in both corals and associated invertebrate and fish populations. The persistence and bioaccumulation of heavy metals in the environment further aggravate these problems, as the toxic effects can endure over time, exacerbating the degradation of coral reef ecosystems.

Mitigation and Conservation Efforts:

Addressing heavy metal pollution in coral reef ecosystems requires a multifaceted approach. Implementing and enforcing stricter regulations on industrial discharges and waste management can significantly reduce the flow of heavy metals into coastal waters. Upgrading wastewater treatment facilities to better capture and remove these contaminants is also crucial. Promoting sustainable coastal development practices can further minimize the introduction of heavy metals into reefs. Engaging local communities in monitoring efforts and raising awareness about the issue fosters more sustainable behaviors. Additionally, ongoing research into how heavy metals affect coral physiology can guide restoration efforts, including selective breeding of more resilient coral species and developing methods to detoxify impacted reefs.

Conclusion

The survival of coral reefs, which are among the most diverse and productive ecosystems on Earth, is severely threatened by heavy metal pollution. This growing environmental issue not only impacts coral health and biodiversity but also endangers the communities that rely on these ecosystems for food, coastal protection, and economic stability. The persistence and bioaccumulation of heavy metals present long-term challenges, making it crucial to adopt comprehensive and urgent conservation strategies. By enforcing stricter pollution controls, upgrading wastewater treatment systems, promoting sustainable development, and involving local communities in conservation efforts, we can help reduce the harmful effects of heavy metals on coral reefs. Additionally, ongoing research into coral resilience and restoration techniques offers hope for the future, allowing us to safeguard these critical ecosystems for generations to come. The time to act is now, as the health of coral reefs is not only an environmental concern but a crucial component of human well-being.

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THE MOST PROMISING & REFRESHING SALAD CROP: CUCUMBER

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Introduction

The **cucumber** (***Cucumis sativus***) is a widely-cultivated creeping vine plant in the family Cucurbitaceae that bears cylindrical to spherical fruits, which probably originated in India from where it seems to have spread eastwards to China and westwards to Asia Minor, North Africa and Southern Europe and subsequently to entire Europe. Although cucumber is known as only a cultivated plant, a Cucumis form *Cucumis sativus* var. hardwickii R. (Alex.), with 2n = 2x = 14 crosses readily with cultivated cucumber. These are grown throughout the world to be consumed as fresh fruits, as slicing cucumber, and as pickles in immature stage.

Other Names

Khira (Benagali), Khira, Kankri, Tihi (Hindi), Maghe Kaayi (Kannaada), Kakkari, Vellari (Malayalam), Thabi (Manipuri), Kakdi (Marathi), Kakodi (Marathi), Kandalu (Sanskrit), Vellarikkay, Karkati (Tamil).

Botany of Cucumber

Cucumber is an annual plant species and is found to be day neutral. Under greenhouse 3 generations per year can be grown. Basically, it is monoecious, trailing or climbing vine with angled, or rough stems. The pistillate flowers are usually solitary with stout, short pedicels. The main stem of monoecious cucumber is usually characterized by three phases of sex expressions. Only staminate flowers are produced in the first phase followed by a phase of irregularly alternating female, male or mixed nodes and finally a phase of only pistillate flowers.

The cucumber is classified as a *pepo*, a type of botanical berry with a hard outer rind and no internal divisions. The cucumber is a creeping vine that roots in the ground and grows up trellises or other supporting frames, wrapping around supports with thin, spiraling tendrils. The fruit of typical cultivars of cucumber is roughly cylindrical, but elongated with tapered ends, and may be as large as 62 centimeters (24 in) long and 10 centimeters (4 in) in diameter. Cucumber fruits consist of 95% water.

Types of Cucumbers

There are many types of cucumbers. Some are commonly found in the supermarket or farmers markets, like English, Persian and Kirby cucumbers, while others are more rare, like white cucumbers. Some are easily digestible, or 'burpless', But what all cucumbers have in common is a cool and refreshing low-calorie crunch to explore in the kitchen.

From fresh salads and chilled soups to chicken dishes, sandwiches and dips, cucumbers are versatile vegetables. Not only will they keep hydrated in summer they'll also give an immune boost, being rich in Vitamins A and C.

English Cucumbers

English cucumbers, also known as seedless, greenhouse, burpless, or European cucumbers, are long and slender with sweet, firm flesh encased in a smooth, thin, dark green skin. With great crunch and small, almost unnoticeable seeds, these are one of the most versatile cucumbers in the kitchen. There’s no need to peel them either, as the skin tends not to be bitter.

White Cucumbers

White cucumbers offer aesthetic interest for their ivory white skins. There are several varieties to choose from, like the fresh and crisp white wonder, a heriloom varieity of cucumber introduced into New York in 1893. White cucumbers are best enjoyed raw, as per English cucumbers.

Persian Cucumbers

These small 'burpless' cucumbers, so known for their easy digestibility, are also prized for their thin, edible skin and very few seeds, much like the English cucumber.Crisper, more flavourful and easier to eat than other cucumber varieties.

Garden Cucumbers

These smooth-skinned and dark green cucumbers are commonly found in North America. Unlike English cucumbers, they have bitter skin.

Lemon Cucumbers

These rounds, yellow cucumbers, the size of a small tennis ball, may resemble the popular acidic Mediterranean citrus fruit in name and colour, but are mild and sweet with a cool, crispy texture. Ideal for salads and pickling. lemon cucumbers are easy to grow making them a popular summer vegetable to brighten up the vegetable patch and summer salads.

Kirby Cucumbers

These small, super-crunchy and mild cucumbers are usually six inches long or less and have bumpy skins and firm flesh. They are the most common variety of pickling cucumbers and are usually recommended in pickle recipes.

Armenian Cucumbers

Also known as **yard-long cucumber**, **snake cucumber**, **snake melon**, they look and taste like cucumbers, used either raw in salads, sandwiches and sushi, or grilled with fish or simply pickled.

Gherkins

Gherkins are small cucumbers, typically those 3 to 13 cm (1 to 5 in) in length, often with bumpy skin, which are typically used for pickling. The word *gherkin* comes from early modern Dutch *gurken* , 'small pickled cucumber'.

Health Benefits of Cucumber

Nutrient-rich cucumbers provide a number of health benefits. Cucumbers are a great source of silica, a trace mineral that strengthens connective tissues. These connective tissues are imperative for muscles, tendons, bone, cartilage, and skin health. Cucumbers have ascorbic acid; compounds rectify skin swelling, fluid retention, burns and itchiness.

Physicians also advised eating cucumbers to remedy stomach ailments and heartburn. In Ayurveda, cucumbers act as a refrigerant, diuretic and febrifuge. They manage urinary tract infections, acne, and quench the thirst.

According to a study published in the *Journal of Food Biochemistry in* 2010, cucumber extracts exhibited antibacterial activity against six strains of bacteria, and antifungal properties against three fungi types.

The fruit is high in fiber and water, low in sugar, has negligible calories, and makes for a satisfying crunchy snack. Cucumbers are one of the few foods high in vitamin K.

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DISEASE MANAGEMENT IN MANGO

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Introduction

Mango (*Mangifera indica* L.) is indigenous to north-east India and north Burma and is considered to have originated in the Indo-Burma region. It is an important fruit crop in tropical and subtropical countries of the world fifth most important fruit crop. Although India is the largest mango producing country; it ranks sixth in terms of productivity. The low productivity in India is due to the wide range of climatic conditions in which it is grown and the various diseases in these climatic conditions. Although mango is affected by large number of diseases but some diseases are of great economic importance and are responsible for high loss in the mango production in our country. Some of these diseases cause heavy loss, and have become limiting factor in mango cultivation. In India, powdery mildew, sooty mould, die back, malformation, anthracnose, etc. cause great economic loss to the crop. As it is not possible to control all diseases completely, it is required that it should be kept under such a level that it does not cause major economic loss. For this purpose, it is required that integrated disease management practices should be adopted for their control. In the present concept, major diseases of mango and their management practices are described.

1. Anthracnose: C*olletotrichum gloeosporioides*

The symptoms occur on leaves, twigs, petioles, panicles and fruits. The incidence of this disease can reach almost 100% in fruit produced under wet or very humid conditions. On leaves, lesions start as small, angular, brown to black spots and later enlarge to form extensive dead areas. Panicles develop small black or dark-brown spots, which can enlarge, coalesce, and kill the flowers .Petioles, twigs, and stems are also susceptible and develop the typical black, expanding lesions. On the lesions and dead portions, minute pink cushion shaped fructifications called acervuli are seen under moist conditions. Fruits may also drop from trees prematurely due to rotting. On immature fruits infections penetrate the cuticle, but remain quiescent until ripening of the fruits begins. Green fruit infections that take place at mature stage remain latent and invisible until ripening.

Favourable conditions:

The high humidity, frequent rains and a temperature of 24 - 32° C coinciding with flowering favours anthracnose infections in the field. The pathogen survives between seasons on infected and defoliated branch terminals and mature leaves. Field infection in developing fruit leads to quiescent infection/Latent infection**.** Later once the ripening starts, lesions begin to develop under post harvest conditions which affect fruit quality and leads to enormous loss.

Management

Proper sanitation of orchard by periodical removal of fallen plant debris and pruning of trees eradicates the fungus and checks further spread of the disease.

Maintaining tree vigour with proper irrigation and fertilization. Fungicide sprays should begin when panicles first appear and continue at the recommended intervals until fruits are picked. Spraying the trees twice with carbendazim (0.1%) or mancozeb (0.2%) or combination of carbendazim 12 % + mancozeb 63 % @ 0.1 % at 15 days interval during flowering to control blossom infection and twice during pea nut stage to prevent fruit infection. Alternate sprayings of carbendazim and mancozeb to avoid development of resistance in pathogen to fungicides. Spraying five times with *Pseudomonas fluorescens* FP 7 (0.5%) from flowering until harvest at 3 weeks interval reduces anthracnose incidence and improves fruit quality.

2. Die back / Fruit Stem end rot: *Lasiodiplodia theobromae*

The disease is characterized by drying of twigs and branches followed by complete defoliation, which gives the tree an appearance of scorching by fire. Tip die back disease occurs on the branches, trunk of infested trees that start drying slowly at first and suddenly branches become completely dried /killed resulting gummy substance oozes out .The dark area advances and young green twigs start withering first at the base and then the twig or branch dies, shrivels and falls called **die back**. This may be accompanied by exudation of gum. In old branches, brown streaking of vascular tissue is seen on splitting it longitudinally.

Stem end rot appears as rotting from pedicel end of fruit during ripening until pathogen remains latent forming appressoria that remains quiescent in the sub cuticular layer in green fruits (Quiescent infection/Latent infection.).

Favourable conditions:

High summer temperatures predispose the plant to attack by the pathogen. Relative humidity of 80% with temperature of 25.9 to 31.5 ^{o}C favours disease development**.** Survives in dead/ diseased twigs, bark of the trees and fallen fruits.

Management

Pruning of infected plant parts from 7- 10 cm below the infection site and pasting the cut ends with Bordeaux paste.

Spraying the trees twice at 15 days interval with carbendazim (0.1%) or combination of carbendazim 12 % + mancozeb 63 % @ 0.1 % during pea nut stage to prevent fruit infection.

Fruits should be harvested with stalk (5 cm), otherwise, the opening must be sealed with wax.

3. Powdery mildew: *Oidium mangiferae*

Symptoms:

Appearance of a whitish, powdery growth of the fungus on leaves, panicles and young fruit which later turns brown and fall. The white growth can also be seen on the under surface of young infected leaves which becomes distorted. Severe infection of young leaves results in premature leaf drop. On mature leaves, the spots turn purplish brown, as the white fungal mass eventually disappears. On developing inflorescence powdery growth leads to drying of flowers. Young fruits at peanut stage are covered with mildew that leads to corky tissue and drops.

Favourable conditions:

Spread of the disease occurs when rains or mists accompanied by cooler nights during flowering especially when the weather is cool and dry .Minimum temperature of 13- 15^{o}C , .maximum temperature of 23-25^{o}C with moderate relative humidity (64-72%) favours disease development. Pathogen survives in affected plant debris and under favourable conditions; air borne conidia is disseminated by wind and attacks new flushes.

Management

Pruning of diseased leaves and panicles.

Three sprays of fungicides at different stages starting with wettable sulphur (0.2%) at the time of panicle initiation followed by dinocap (0.1%) subsequently followed tridemorph (0.1%) at 15-20 days interval. In addition, foliar spraying with mycobutanil @0.1% or triademefon @0.1% or carbendazim @0.1% or thiopahante methyl @ 0.1% was found effective against the disease.

4. Grey leaf Blight: *Pestalotia mangiferae*

Symptoms

Brown spots develop on the margin and at the tip of the leaf lamina which coalesce covering the leaf margin and becomes dark brown. Black dots appear on the spots which are acervuli of the fungus. If infection starts from tip, it advances on either side of mid rib and within 3-4 months severe defoliation.

Favourable conditions:

Heavy infection is noticed during the monsoon when the temperature is 20-25^{o} C and high humidity. Conidia survive on mango leaves for over a year. Spreads through wind borne conidia and rain splashes.

Management

Removal of infected plant parts. Spraying one time with copper oxychloride @ 0.25 % or mancozeb @ 0.25% or bordeaux mixture @ 1.0% at the visual appearance of disease.

5. Sooty Mould: *Capnodium mangiferae*

The disease is common in the orchards where mealy bug, scale insects and hoppers are not controlled efficiently. Honey dew secretion by insects make the fungi produce mycelium which is superficial and dark and forms black encrustation on leaves. In severe cases, the trees turn completely black due to the presence of mould over the entire surface of twigs and leaves.Presence of a black sooty mould on the leaf surface adversely affects the photosynthetic activity of the leaf and thereby fruit set is reduced.

Favourable conditions:

Reduced ventilation favours sooty growth on leaves. High humidity spreads the disease within orchard. Honey dew secretions from insects stick to the leaf surface and provide necessary medium for fungal growth. Conidia spread by rain splashes.

Management

Pruning of affected branches and their prompt destruction .Spraying systemic insecticides like to control insects. Spraying of 5 per cent starch (1kg Starch/Maida in 5 litres of water. Boiled and diluted to 20 liters) helps to control the disease as dried starch flakes removes the fungus.

6.Mango malformation: *Fusarium moniliforme var. subglutinans*

Symptoms

Three types of symptoms: bunchy top phase, floral malformation and vegetative malformation.

Bunchy top phase in nursery at 4-5 months old, bunching of thickened small shoots, bearing small rudimental leaves. Shoots remain short and stunted giving a bunchy top appearance.

Vegetative malformation induces excessive vegetative branches of limited growth in seedlings. They are swollen with short internodes forming bunches of various size and the top of the seedlings shows bunchy top appearance.

Inflorescence malformation showed variation in the panicle. Reduction in length of primary axis and secondary branches of panicle makes the flowers to appear in clusters.Secondary branches are transformed into number of small leaves giving a witches broom appearance. Malformed head dries up in black mass and persist for long time. Such panicles dot not bear.

Favourable conditions:

Diseased propagated material spreads disease. The fungus does not sporulate insitu but sporulates on dried malformed panicles. The disease is severe in North West region at temperatures between 10-15 ^{o}C during December to January before flowering. Disease is mild in areas with 15-20 ^{o}C, sporadic between 20-25 ^{o}C. Occurrence of malformation differs based on age of plants. Plants at 4- 8 years are susceptible. In some cases mites have been reported to be carrying the fungus and cause spread.

Management

Diseased plants should be destroyed. Use of disease free planting material.Incidence reduced by spraying 100-200ppm NAA during October. Pruning of diseased parts along the basal 15-20 cm apparently healthy portions followed by the spraying of carbendazim (0.1%) or captafol (0.2%).

8. Bacterial leaf black spot / canker (*Xanthomonas campestris pv. mangiferae-indicae*)

Symptoms

The disease causes fruit drop (10-70%), yield loss (10-85%) and storage rot (5-100%). Many commercial cultivars of mango are susceptible to this disease. Bacterial leaf spot is noticed on the leaves as angular water soaked spots that become necrotic and dark brown and viscous bacterial exudates deposit on these necrotic portions that become corky and hard after drying. Sometimes, longitudinal cracks also develop on the petioles. Cankerous lesions appear on petioles, twigs and young fruits. The water soaked lesions also develop on fruits which later turn dark brown to black.

Favourable conditions:

The bacteria enters through natural openings such as stomata, wax and oil glands, leaf and fruit abrasions, leaf scars, and at the apex of branches in the panicle. High humidity, surface wetness and wind accompanied with rain cause most rapid and maximum dissemination of bacteria. Survives in infected plant parts and spread through rain splashes and wind. Disease is rapid during rainy days.

Management:

Field sanitation and removal of affected plant parts. Three sprays of Streptocycline (200ppm) or Agrimycin-100 (100 ppm) after first visual symptom at 10 days intervals. Monthly sprayings of Copper oxychloride (0.3%) checks the further spread. Removal of diseased fruits under storage.

9.* Red Rust (*Cepbaleuros virescens)

The disease is caused by an algae that causes reduction in photosynthetic activity. Initially the spots are greenish grey and velvety in texture which finally turn to rusty spots on leaves and twigs. In severe cases, defoliation of leaves there by lowering vitality of the host plant.

Favourable conditions:

Disease is common in closed plantations. High humidity favours the development of fruiting bodies.

Management:

Supply of balanced nutrients to the plants and two sprays of Bordeaux mixture (1%) or copper oxy chloride (0.3%) in the month of July at 15 days interval.

Integrated Disease Management Strategies

- ✓ Proper sanitation of orchards by removal of fallen plant debris and pruning of trees during the months of July –August eradicates the fungus and checks the spread of diseases.
- ✓ Application of Bordeaux paste on the cut ends of branches prevents entry of pathogens.
- ✓ During flowering, spray twice with carbendazim (0.1%) at 15 days interval to control blossom infection and twice during pea nut stage to prevent fruit infection by anthracnose and stem end rot. Alternate sprayings of carbendazim and mancozeb to avoid

development of resistance in pathogen to fungicides. carbendazim 12 % + mancozeb 63 % @ 0.1 % can be recommended as an alternate for better control. Three sprays with wettable sulphur (0.2 %) at 15 days interval starting from panicle initiation to prevent powdery mildew (sprays can be reduced depending on disease incidence)

- ✓ From fruit set until 15 days before harvest, alternate spray with carbendazim (0.1%) with a copper oxy chloride (0.3 %) every 14–28 days which takes care of fruit infections by anthracnose, stem end rot and bacteria. Spraying five times with *Pseudomonas fluorescens* FP 7 (0.5%) from flowering until harvest at 3 weeks interval reduces anthracnose incidence and improves fruit quality.
- ✓ Spraying of 5 per cent starch solution to remove sooty mould growth. Avoid injuries /damage on the fruits during picking and transit.
- ✓ Post harvest infection due to fungal pathogens are controlled by dipping the fruit in hot water (52 ± 10°C) or hot water in combination with carbendazim (0.05%) for 5 minutes..

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GENOMIC RELATIONSHIP OF *STYLOSANTHES SP.*

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Introduction

Stylosanthes genus is a diverse group of species with a wide distribution in tropical, subtropical and temperate regions of the America, tropical Africa and south east Asia. Four major species of stylo namely *S. scabra*, *S. hamata*, *S. humilis and S. guianensis* are widely used as forage legumes in tropical regions More than 90% of them were collected in Brazil, with Colombia and Venezuela each contributing about another four percent of the collections.

Classification of *Stylosanthes sp*

***Stylosanthes scabra*:** This is most important species for drier regions as this is hardy erect woody type and get well adapted in low rainfall areas. It has been also found suitable for semi-arid areas of Maharastra, Andhra Pradesh, Karnataka and Tamil Nadu. It has been successfully grown on degraded soil with low fertility, shallow sandy clay loam to black cotton and red chalaka soils. It is suitable for hill slopes and degraded areas and can establish in areas with about 325 mm rainfall.

***Stylosanthes hamata* (Caribbean stylo):** This is one of the most adaptable species in India due to its intrinsic nature of fast growth, soft stem and leafy in nature. In comparison to all other species introduced in India, *S. hamata* have been observed highly diversified species in terms of both adaptation and yield performance including seed production. The main advantage of this species is its land covering capacity to maintain and conserve moisture and that leads to fast growth. Both diploid and tetraploid lines have been reported in this species. However, tetraploid species is more prominently used as forage.

***Stylosanthes humilis*(Townsville stylo):** This species was once the major stylo species in Australia but due to susceptibility to anthracnose disease much of the areas was destroyed in 1970s and now it has little significance. IGFRI indicated least production potential but better tolerance for salinity of this species in comparison to other. Presence of hairs on stems and leaves are some of the important features helpful in identifying the species.

***Stylosanthes guianensis*:** This species has been found suitable for humid and higher rainfall regions. Because of this reason this species has not performed well at Jhansi. It has been found well suited to high rainfall areas of Assam, west Bengal, Maharstra and Andaman and Nicobar Islands. It is leafy and provides good quality forage. Due to larger leaves it has been identified as a suitable for the production of leaf meal. In China and Brazil this species is largely used for such purposes. Flowering is also late in this species.

***Stylosanthes seabrana*:** This is a new species introduced in India in the year 1998 through ACIAR project. This is one of the progenitor of hardy *S. scabra* and have shown great promise for this country. Evaluation at IGFRI and different locations has shown great potential and future of this species. It is highly nutritious and showed better establishment in different types of soils. It is diploid in nature and has been selected from the original field of *S. scabra.*

GENOMIC RELATIONSHIP

S. scabra as an allotetraploid species ($2n = 40$) with a putative diploid A genome progenitor *S. hamata* or *S. seabrana* ($2n = 20$) and the B genome progenitor *S. viscosa* ($2n = 20$).

Breeding objectives

1.Humid regions: *S. guianensis*

- Good drought tolerance
- Adapatation to acid soils, low fertile oxisols and ultisols
- Fertiliser responsive
- Susceptibility to anthracnose in humid regions

2.Sub humid regions: *S. capitata and S. guianensis var pauciflora*

- Late flowering and many branched
- fine stemmed type and narrow leaflets
- viscid hairs on stem and leaves

VARIETIES IN TAMIL NADU

1. *S.hamata (Annual)*
2. *S.scabra (Perennial*)


S. hamata *S. scabra*

Based on modeling using the available Indian data pertaining to *S. hamata, S. scabra and S. guianensis* indicated widespread suitability of soils for *S. hamata and S. guianensis*. Due to requirement of high rainfall *S. guianensis* is likely to be restricted to coastal regions of Southern India. *S. scabra* was shown to be moderately suitable over a wide area, but less suitable in central and western districts.

Since the introduction of Stylosanthes in India, Indian Grassland and Fodder Research Institute (IGFRI), Jhansi provided a strong platform for the evaluation of five species namely *S. scabra, S. hamata, S. viscosa, S. humilis and S. guianensis*. Genotypes of *S. scabra* was more tolerant to drought over lines of other species as evidenced by high leaf thickness, more proline accumulation, contents of malondialdehyde (MDA), sugars, starch and chlorophyll and low carbon isotope discrimination (CID. *S. humilis* as the best species for marginal lands. In contrast, *S. guianensis* was the most suitable species for the fodder production in areas of Kerala and Manipur.

HARVESTING

First harvest can be taken 75 days after sowing at flowering stage and subsequent harvests depending upon the growth.

GREEN FODDER YIELD

It is to be noted that during the first year, the establishment after sowing is very slow and the yield is low. Later on when the crop establishes well it yields about 30 to 35 t/ha/year from the third year onwards.

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PROSPECTS OF BLOCKCHAIN TECHNOLOGY IN INDIAN AGRICULTURE

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Introduction

A blockchain is a distributed ledger that duplicates and distributes transactions across the network of computers participating in the blockchain. Blockchain technology is a structure that stores transactional records, also known as the block, of the public in several databases, known as the "chain," in a network connected through peer-to-peer nodes. Typically, this storage is referred to as a 'digital ledger'. Every transaction in this ledger is authorized by the digital signature of the owner, which authenticates the transaction and safeguards it from tampering. Hence, the information the digital ledger contains is highly secure. Blockchain is a method of recording information that makes it impossible or difficult for the system to be changed, hacked, or manipulated, in other words, anybody can see the data, but they can't corrupt it.

The blockchain technology allows peer-to-peer transactions to take place transparently and without the need for an intermediary like a bank or a middleman in the agriculture sector. By eliminating the need for a central authority, the technology changes the way that trust is granted – instead of trusting an authority, trust is placed in cryptography and peer-to-peer architecture. It thus helps restore the trust between producers and consumers, which can reduce the transaction costs in the agri-food market.

The blockchain technology offers a reliable approach of tracing transactions between anonymous participants. Fraud and malfunctions can thus be detected quickly. Moreover, problems can be reported in real-time by incorporating smart contracts. This helps address the challenge of tracking products in the wide-reaching supply chain due to the complexity of the agri-food system. The technology thus provides solutions to issues of food quality and safety, which are highly concerned by consumers, government, etc.

Prospects of blockchain technology in Agriculture

a. Agricultural Insurance

Agricultural insurance schemes are traditionally a well-recognized tool to manage weather related risks. Agricultural insurances differ with respect to how losses are assessed and consequently how payouts are triggered. Insurances that indemnify farmers based on a damage assessment that was made by an expert on the farm are denoted as indemnity-based insurances. Indemnity based insurances are able to precisely cover losses, however, they are prone to problems arising from asymmetric information problems. Motivated by the drawbacks of indemnity-based insurances, the idea of index-based insurances was born either as an alternative or complement to the classical products. Here the payout is not triggered by the loss itself but by a measurable index, such as rainfall at a nearby weather station. However, discrepancies between payout and on-farm loss can occur which is denoted as basis risk. Blockchain can contribute to improving index insurance in two dimensions. First, payments can be made timely and automated based on weather data that triggers the payout as defined in a smart contract. Second, weather information and other data sources, such as plant growth information or data collected by farm machinery, can be automatically integrated via a smart oracle improving basis risk reduction and making the index determination and payout process more efficient.

b. Smart Agriculture

A key issue of establishing smart agriculture is developing a comprehensive security system that facilitates the use and management of data. Traditional ways manage data in a centralized fashion and are prone to inaccurate data, data distortion and misuse as well as cyber-attack. For example, environmental monitoring data is generally managed by centralized entities that have their own interest. They can manipulate the decision-making related to data. The blockchain technology serves to store data and information that various actors and stakeholders generate throughout the entire value-added process, from seed to sale, of producing an agricultural product. It ensures that the data and information are transparent to the involved actors and stakeholders and all recorded data are immutable. Many smart farming models are proposed and implemented based on the joint application of IoT and blockchain technology. The idea of "smart farms" may be introduced as a result of the integration of all these various blockchain-based applications in agriculture. These sustainable farming methods improve the quality of the environment, integrate technology with biological cycle controls, and make farm operations profitable. Thus, smart farming involves collecting and sharing large amounts of data on farming methods, weather, and animal health. Smart farming uses a lot of digital tools and remote sensors to get the information it needs in advance, such as fertilisers, soil mapping, crop yields, and the machinery used. Sensors are also used in smart farming to detect animal health issues and upcoming reproductive events. This type of livestock data is gathered by keeping an eye on the movements of the animals as well as their body temperature, pulse rate, and tissue resistivity. Additionally, GPS is used to determine where they are. Some companies are investing heavily in establishing a smart agricultural supply chain in rural areas of the country. Smart agriculture with blockchain does not lower, if not raise, the technological barrier for farmers to participate. Importantly, it is better motivated to collect trustworthy data from large farmers than from smallholders for uploading to the blockchain. Large farmers are more likely to be involved in blockchain-based smart agriculture and benefit from it. This thus can create or increase the discrepancy between large farmers and smallholders.

c. Food Supply Chain

The food supply chain has grown longer and more intensive than ever because of globalization trends. However, there are several challenges in the food supply chain, including food safety, quality, traceability, trust, and supply chain inefficiencies. These factors burden the economy and society and endanger customers' health. Blockchain technology contributes to the resolution of many of these challenges by facilitating the establishment of trust between producers and customers. Offering specific product information within the blockchain can considerably increase transparency in this process. This has far-reaching repercussions for businesses and farmers alike. It enables businesses to raise the value of their products and hence increase their market competitiveness.

It would also make it extremely improbable that providers of low-quality or fraudulent goods would be able to stay in business for very long if their tactics continued. From a consumer standpoint, the usage of blockchain can be critical in providing people with trustworthy and legitimate information about how their food is produced. It may be used to address a wide range of customer concerns about food quality, safety, and environmental friendliness. Consumers have more flexibility to communicate with food producers as they better grasp their food production process. When considering the benefits of blockchain from a regulator's perspective, it is evident that this technology provides reliable information to required entities to assist them in enforcing efficient regulations. The current blockchain technology in the food supply chain is still in the early stages of development. At the same time, there are many immature and imperfect places in the process of blockchain technology implementation. Furthermore, the application of blockchain technology needs wide participation and collaboration of involving parties in the food supply chain, which is significant to play its full role. Due to its characteristics of transparency, security and decentralization, blockchain technology makes it possible to track the information of food quality in the entire supply chain. This helps prevent fraud in food transaction and reduce the costs of food supply chain management. All parties, including producers, consumers and government regulatory bodies, can thus be benefited.

d. Digitization of Land Records

The blockchain in the land registry is used for secure transfer of land property. The transparent nature of blockchain enables to track the changes made in land documents. Advent of blockchain technology in the land registry is playing a very beneficial role in this developing era. It is helping in uplifting the poor, and marginalized section of the society in fighting illegal authorization of land. The current system for land registration is full of duplicity and inefficiencies, due to which the land records are not protected, and citizens are the one those have to bear the most of it. Similarly, there are thousands of people who face such a crisis. With the help of blockchain, all the records are preserved all the time, are easily accessible, none can ever doubt the originality of the records, records are fed in the system permanently.

Therefore, no one can ever manipulate it, and the records can be seen by any participant anytime. For the validation or proof of this blockchain technology in the land registry, the concept of the smart contract is followed. A smart contract is the legal proof of ownership and contain the history of the property. The buyer is confident for land bought, that it is original without any duplicity, and the seller is the lawful owner of the land, which abandons the probabilities for any disputes later. The use of smart contracts gears up the procedure of land titling by updating the record automatically.

e. Access to finance

The financing system in agriculture using blockchain technology aims to provide a more efficient, transparent, and secure way of lending and renting in the agricultural sector. By leveraging blockchain technology, the Rental and loan system in agriculture can provide access to finance for small-scale farmers who would otherwise not qualify for traditional loans and eliminate intermediaries such as banks and brokers, leading to lower transaction fees, quicker processing times, and a more streamlined rental and loan process. Blockchain technology provides an immutable and transparent record of transactions, increasing trust and reducing the likelihood of fraud or error as well as provides enhanced security, as transactions are secured using cryptography and stored in a decentralized network. It allows farmers and lenders to interact directly, creating a more collaborative and community-driven approach to agriculture by connecting borrowers with a wider pool of lenders, potentially leading to lower interest rates.

f. E-Commerce of Agricultural Products

Cash on delivery and Logistics service are the most crucial challenges faced by e-commerce companies, especially in developing countries. Besides, e-commerce retailers also need to handle time-demanding small orders with diverse items, which causes high operating costs for e-commerce companies. Blockchain technology provides private key encryption which is a powerful tool that provides the authentication requirements. It can thus link the data of all aspects of planting and harvesting of agricultural products safely and unchangeably. Blockchain technology could enable supply chain management more efficiently than traditional monitoring mechanisms by lowering signaling costs for each entity. Every link in the supply chain – the producer, the place of origin, the shipping company, the destination, the multimodal transport, the warehouse and the final last mile – represents a "block" of information, with the advantage of visibility, aggregation, validation, automation and resiliency. The blockchain provides a digital payment solution with zero rates. Through the decentralized mechanism, the distributed accounting system of the blockchain is time-stamped, so that all information on the chain is transparent and unmodifiable. Consumers will be liberated from fakes and regain confidence in e-commerce. Many agricultural products are produced by households. Due to the low transaction volume and small scale, traditional e-commerce is neither willing nor able to provide services for them, thus excluding these participants from the market. Blockchain technology can greatly reduce transaction costs and incorporate them into the market again.

Way Forward

According to data by NASSCOM, India had around 450 agritech startups in 2022, with the number growing at 25% year-on-year. Further, a report estimates that agritech startups in India offer a $24 billion opportunity, and the industry's potential is still largely untapped. Blockchain is a groundbreaking technology in the Agritech ecosystem. Its potential is only now being discovered, and even then, we have barely scratched the surface of it. By leveraging blockchain, agritech platforms can reinforce the dynamics of Agri trade, which is necessary given the rise in demand for food supply and security, traceability in the food supply chain and enable transparency in the agriculture ecosystem. Blockchain's power can also be harnessed for multiple other purposes, including ensuring data authenticity and food quality and real-time tracking of transactions. For agrarian economy like India, blockchain technology can prove to be a game change as it is capable of providing tamper proof, accurate data regarding land holdings, farm inventory, credit sources and food tracking.

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IMPACT OF RANCIDITY IN NUTRITIONAL PROFILE OF PEARL MILLET FLOUR (PENNISETUM GLAUCUM (L.) R.BR.)

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Introduction

Pearl millet is the 6th most important crop worldwide and most imperative crop after rice, wheat and maize in India. It can be grown in marginal and adverse agro-ecological environments, where the survival rate of other crops is very low; hence pearl millet is define as a climate resilient crop. It has a strong nutritional background in term of minerals density, protein and carbohydrates profile and termed as a Nutri-cereal. It also yields high biomass, so it is a good source of forage, stover and feed. It is one of the most preferred cereal crops for poor and marginal farmers. However, apart from all these qualities, it is associated with one drawback that is rancidity of its flour in few hours to few days after milling at room temperature and relative humidity. Rancidity causes the mousy odour and off taste, which is not eatable by the human beings and consumption of rancid flour can causes the serious health issues.

Rancidity

Rancidity word was derived from latin word rancidus which means stinking. It is a biochemical process of fat with oxygen, which converts the long chain fatty acid into the short chain compounds, as a resultant butyric acid is formed, which imparts rancid taste in food. The process of decomposition of lipid, oil and fats either by hydrolysis or oxidation is called rancidification. It is one of the most vital parameter in order to check the quality of pearl millet flour.

Affecting factors of rancidity in pearl millet

There are many reasons for rancidity development in pearl millet, which are oxidation of unsaturated fatty acid, high peroxide activity, enzymatic modifications in C-glycosylflavones, presence of phenolics in meal and their enzymatic degradation. While C-glycosylflavones and phenolics have no ability to produce rancidity without peroxidase and lipase activity.

High fat content:

Pearl millet grains contain approximately 7 to 7.9% of fat content and mostly abundant with unsaturated fatty acids like oleic (C18:1), linoleic (C18:2) and linolenic (C18:3) and also contain small amount of saturated fatty acids such as palmitic (C16:0) and stearic (C18:0). High triglycerides profile of pearl millet grain is the main reason for its deterioration by lipolysis and oxidation processes. While unsaturated fatty acids concentration is very high in pearl millet grain and get readily oxidise from surrounding oxygen and moisture which produce unpleasant taste in its flour.

Lipase activity:

Lipase enzyme or triacylglycerol acylhydrolase is intensed in the pericarp, aleurone layer and germ of pearl millet grain. Lipase convert the complex form of triacylglycerol to simple form and also release free fatty acid and glycerol.

$$\text{Triacylglycerol} + 3H_2O \underset{\text{lipase}}{\Longleftrightarrow} \text{Glycerol} + 3 \text{ fatty Acid}$$

Peroxidase:

Peroxidase causes the rancidification of pearl millet flour through oxidation.

$$\text{Electron donor} + H_2O_2 \xrightarrow[\text{Peroxidase}]{} \text{Oxidised electron donor} + 2H_2O$$

C-glycosylflavones:

C-glycosylflavones is a class of flavonoids which includes Glucosylvitexin, glucosylorientin and vitexin. Reichert (1979) acknowledged C-glycosylflavones viz., glucosylvitexin, glucosylorientin and vitexin that were 3-pH-sensitive pigments. The concentration of C-glycosylflavones was 124 mg/100 g in pearl millet grain and outer layers was much dense with C-glycosylflavones as compared to inner portion of the seeds reported by Reichert and co-workers (1980). Reddy et al. (1986) identified these compounds as the agents which produce unpleasant odour in ground pearl millet.

Oxygen concentration:

The oxygen availability is an imperative factor for rancidity as oxidation process is carried out in presence of oxygen (Berger, 1994).

Effect of temperature:

Temperature influences on shelf life of cereals grain. The rate of reaction of oxygen with fats is increase as the temperature increase (Berger, 1994).

Effect of light:

Light is also a rancidity promoting factor as oxidation of fat is increased in presence of light through photo-oxidation (Hamilton, 1994). The oxidation process through photosensitisation involves substrate activation, which consequently reacts with unsaturated fatty acids (W¹sowicz E et al., 2004).

Although pearl millet has strong nutritional background but its utilization becomes limited because of some obstacle like undesirable colour of its flour and products and also unpleasant odour in its flour during storage. Pearl millet flour has very short life, as it rapidly gets rancid, that produces off odour in its flour and cooked products. Pearl millet is a staple food in many states like Rajasthan, Haryana and Uttar Pradesh in India. Rural peoples of such regions have mainly depends on it for their daily energy requirements and household women pound it into flour traditionally, but only few days requirement can be completed as rancidity destroys its quality. Commercialization of pearl millet flour is also very less because of rapid rancidity.

Indicators of rancidity:

Some parameters can be used to identify the rancidity level in pearl millet flour are as follows:

Acidity of fat:

Acidity of fat is a perceptive and imperative parameter to find out the product quality of cereals. It can be a marker of biochemical changes during storage of cereal and its product. Acid value (AV) or free fatty acid (FFA):

The acid value (AV) is a common and important factor for the measurement of fats and oils. It estimates the quantity of KOH (in mg) required to neutralize the organic acids of fat (one gram) and also estimation of free fatty acids (FFA) in fat and oil.

Peroxide value (PV):

A peroxide value indicates the oxidation or hydrolysis of unsaturated fats and oils. Auto-oxidation is the process of free radical reaction with oxygen that occurs most commonly in unsaturated fatty acids which can be determined by peroxide value; hence the level of peroxide value indicates the level of rancidity.

Rescue of pearl millet flour from rancidification:

Anti-nutrients or Anti-oxidants:

Anti-nutrients are naturally occurring compounds [polyphenols, tocopherols (vitamin E), flavonoids and ascorbic acid (vitamin C)] in a variety of cereals and legumes that can also be produced artificially [propyl 3,4,5-trihydroxybenzoate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT)], which interfere with absorption of minerals and vitamins (Jiang et al., 2016). Polyphenols, an anti-nutrient highly concentrated in pearl millet grain and act as a defender of seed from pest, bugs and others. It protects the cereals flour and fat containing food against rancidity by preventing the oxidation fat and also prevents the free radicals formation.

Pearl millet generally has no anti-nutrients factor compared to other crops like sorghum which is condensed with tannin. Pearl millet germ mainly contains nicotinic acid and phytic acid while the peripheral area of seed contains polyphenols (Simwemba et al. 1984). Gray colour of pearl millet seed is due to polyphenols which minimize the use of starch and protein (Pawar and Parlikar 1990), either by binding directly with protein or inhibition of digestive enzymes like amylase and trypsin (Singh 1984).

Storage techniques:

Currently, many studies have explained that the shelf life of pearl millet flour can be enhanced by proper storage, combination of fermentation and malting. Akinola et al. (2017) studied the effect of different pre-processing techniques like fermentation, debranning, malting and blanching on the physiochemical properties of pearl millet flour in order to improve pearl millet flour utility in agricultural or food industries.

Challenges:

1. Anti-nutrients like Polyphenols will reduce the rancidity of pearl millet flour but increase in anti-nutrient will decrease the nutritional profile of pearl millet and also cause health effects.
2. Using breeding strategies for the development of resistant/less susceptible varieties/hybrids of pearl millet in order to overcome the rancidity.

Future prospective:

Research need to be focused on the variability in the rancidity profile existing among lines in pearl millet germplasm collections, identify lines having low susceptibility to rancidity and explore the pre-processing, processing and post-processing options of using these low rancidity profile lines to obtain shelf-stable pearl millet flour. The ultimate aim is to reduce drudgery of women and further promote the commercialization and usage of this Nutri-cereal.

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NEGLECTED CROP: THE GLOBAL SOLUTION TO FOOD AND NUTRITION SECURITY

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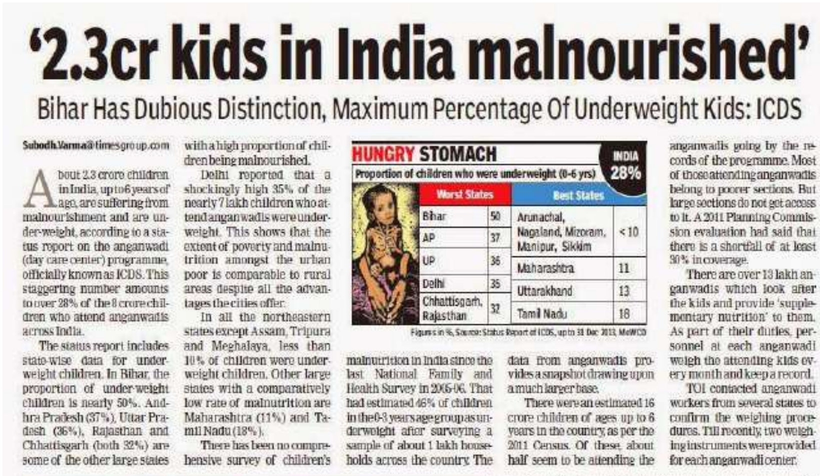
Introduction

Nutritional insecurity is the major menace in the world that needs to be addressed on a priority basis. Globally, it was estimated that > 2 billion people, including nearly 50% of children in the age group of 6 months to 5 years, are deficient in essential micronutrients and vitamins. Deficiencies in micronutrients mainly of Fe, Zn, iodine, vitamin A and folate have a destructive consequence that adds to the burden of food deficiency due to poverty. Among the population of the developing world including India, the most commonly followed diet is vegetarian which largely depends on cereals and legumes as there is limited access to fruits, meat, egg, milk products etc. This dietary pattern is the main cause of micronutrient deficiencies. Globally, Fe and Zn deficiencies are major health problems and various dietary factors influencing the development of Fe deficiency anemia include low dietary Fe intake and/or intake of compounds that reduce its bioavailability.

Similar to Fe, Zn deficiency is largely related to inadequate intake or absorption of Zn from the diet. Sometimes people get enough Zn but still they face Zn deficiency which is mainly due to high levels of inhibitors like fiber and phytate in the diet. For normal physical activities of the human body, the daily requirement of Fe is 8 mg for adults and 10 mg for children. The recommended consumption of Zn for children 1-8 years old is up to 3-5 mg, for 9-13 years old is 8 mg of Zn / day. After the age of 14, the requirement increases to 11 mg/day, this is required for all adults.



'2.3cr kids in India malnourished'

Bihar Has Dubious Distinction, Maximum Percentage Of Underweight Kids: ICDS

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About 2.3 crore children in India, up to 6 years of age, are suffering from malnourishment and are under-weight, according to a status report on the anganwadi (day care center) programme, officially known as ICDS. This staggering number amounts to over 28% of the 8 crore children who attend anganwadis across India.

The status report includes state-wise data for under-weight children. In Bihar, the proportion of under-weight children is nearly 50%. Andhra Pradesh (37%), Uttar Pradesh (36%), Rajasthan and Chhattisgarh (both 32%) are some of the other large states with a high proportion of children being malnourished.

Delhi reported that a shockingly high 35% of the nearly 7 lakh children who attend anganwadis were underweight. This shows that the extent of poverty and malnutrition amongst the urban poor is comparable to rural areas despite all the advantages the cities offer.

In all the northeastern states except Assam, Tripura and Meghalaya, less than 10% of children were under-weight children. Other large states with a comparatively low rate of malnutrition are Maharashtra (11%) and Tamil Nadu (18%).

There has been no comprehensive survey of children's malnutrition in India since the last National Family and Health Survey in 2005-06. That had estimated 46% of children in the 0-3 years age group as underweight after surveying a sample of about 1 lakh households across the country. The data from anganwadis provides a snapshot drawing upon a much larger base.

There were an estimated 16 crore children of ages up to 6 years in the country, as per the 2011 Census. Of these, about half seem to be attending the anganwadis going by the records of the programme. Most of those attending anganwadis belong to poorer sections. But large sections do not get access to it. A 2011 Planning Commission evaluation had said that there is a shortfall of at least 30% in coverage.

There are over 13 lakh anganwadis which look after the kids and provide 'supplementary nutrition' to them. As part of their duties, personnel at each anganwadi weigh the attending kids every month and keep a record.

TOI contacted anganwadi workers from several states to confirm the weighing procedures. Till recently, two weighing instruments were provided for each anganwadi center.

HUNGRY STOMACH

Proportion of children who were underweight (0-6 yrs) — INDIA 28%

Worst States		Best States	
Bihar	50	Arunachal, Nagaland, Mizoram, Manipur, Sikkim	< 10
AP	37		
UP	36	Maharashtra	11
Delhi	35	Uttarakhand	13
Chhattisgarh, Rajasthan	32	Tamil Nadu	18

Figures in %, Source: Status Report of ICDS, up to 31 Dec 2013, MoWCD

Fig 1. Malnutrition status in India; on the right: Rabina's photo, the story of a malnourished child: Two and a half-year-old Rabina weighs 6.5 kg. A healthy child of his age should weigh at least 8 kg. But Rabina could not escape the curse of being born in Madhya Pradesh's Shivpuri district - famous for the past 30 years as one of the country's most malnourished districts.

Easily accessible diet Balanced diet can't access this food due to poverty

Fig 2. The schematic diagram shows that a balanced diet is not available to the poor due to poverty and mainly depends on staple crops to meet their daily energy requirement.

To overcome Fe and Zn deficiency, there are several strategies that include dietary diversification, food fortification, external supplementation and biofortification. The most accepted and reliable approach is biofortification, as it is a highly cost-effective and sustainable approach to enhance the essential micronutrients in staple food crops.

Why pearl millet serves a model crop for food and nutritional security?

Staple crop

To march towards "Micronutrient malnutrition free India" millets to be included in daily diet which is a rich source of micronutrients. Millets can play a prime role in tackling the challenge of nutrition insecurity, worldwide. In India, the major crops are wheat, rice, maize, millets, and pulses. Pearl millet is less popular than wheat and rice except in some states in India. While it is serving as a staple food in states like Uttar Pradesh, Maharashtra, Gujarat, and Rajasthan. The inhabitants of such states cultivate it and consume it as the main food.

Climate resilient crop

At present, the weather is changing and the water level is falling. In the coming days, it will be difficult to irrigate crops, but pearl millet can be grown in a vast range of environmental conditions, including repeated drought events, heat stress, and low soil fertility. It can also grow in areas with an annual rainfall of less than 300 mm, as evidenced by the average annual rainfall received in Rajasthan. Therefore, it provides a source of food security. It is a versatile cereal that provides food, fuel and fodder in Asia and South Africa and is cultivated on more than 27 million hectares. Therefore, pearl millet is one of the most essential staple crops in West and Central Africa.

Health benefits

Pearl millet is a very nutritious cereal compared to other cereals. It is a principal source of protein, vitamins, fat, minerals, and micronutrients like Fe, Zn, Ca, K etc. for millions of poor populations where it is cultivated. The total amount of Fe in pearl millet will provide about 60% of the Estimated Average Requirement (EAR). It is highly fibrous (12g /kg) compared to other food grains. It is also high in fat content (50 mg/kg), vitamin B complex (thiamine, riboflavin, and niacin), Vitamin A, and folic acid than wheat. Among micro-nutrients, it is loaded with an abundance of Fe and Zn content. Hence, Pearl millet is a highly nutritious cereal whereas bioavailability is low, because of the presence of certain anti-nutritional factors like phytic acid, polyphenols etc. Polyphenols content was found to range from 491 to 7.65 g /kg whereas phytic acid content ranged from 3.54 to 8.25g /kg. Protein and starch digestibility of pearl millet is low because of the anti-nutrients in grain. The digestibility for protein ranged between 54.2% to 59.2 %, whereas 12 to 18.7 mg maltose was released/g for starch. Recently, pearl millet is getting attention for its good nutritional quality in the medical field. Pearl millet is a sustainable cereal with good dietary properties for diabetic patients. It has superior glycemic control over wheat and rice because of the presence of slowly digestible starch (SDS) and resistant starch (RS).


Fig 3a. Millet- staple food of ancient India **3b**. Biofortified pearl millet can fight iron deficiency problems

The Government of India declared '2018' as "National Year of Millets" to march towards "Malnutrition Free India" by the end of the year 2022. In this regard, The Indian Council of Agricultural Research (ICAR) has established minimum levels of Fe and Zn to be bred into national varieties of pearl millet. The UN Food and Agriculture Organization (FAO) also decided the year 2023 to be the **"International Year of Millets**.

Although millet contains high levels of Fe and Zn, these micronutrients fall below the HarvestPlus target level when a breeder improves the crop for higher yields. Therefore, the biofortification strategy helps the breeder to improve the micronutrient profile of the grain with higher yield. The HarvestPlus program of CGIAR (The Consultative Group on International Agricultural Research) targeted crops to genetically improve the nutritional background of crop varieties in different countries with their desired traits through traditional breeding programs.

Conclusion and future line

Biofortification of pearl millet with Fe and Zn can address the mania very quickly. In a way, soil or foliar supplementation with micronutrient fertilizer is practical option but not sustainable and economically feasible for resource poor farmers particularly in semi-arid and arid regions where pearl millet is a prime crop. Hence, biofortification in pearl millet comes out to be a popular, cost –effective and long lasting approach among underdeveloped and developing nation.

In future, designing breeding programs for making micronutrient available at needed proportion, more attention should be paid to the association between Fe and Zn content, with increase in promoters and reduction in anti-nutritional elements which hinder micronutrient bio-availability.

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GOAT FARMING AND RURAL EMPOWERMENT: HOW IT'S CHANGING LIVES IN INDIA

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Introduction

Rural India is undergoing significant socio-economic transformations, and goat farming is at the heart of this change. With minimal investment and high returns, goat farming has become a sustainable source of income, especially for small and marginal farmers, landless laborers, and women. Known for its adaptability to India's diverse climates, goat farming has proven to be a viable livelihood option. This article explores how goat farming contributes to rural empowerment by creating sustainable income opportunities, enhancing food security, empowering women, and promoting inclusive development.

1. The Growing Importance of Goat Farming in India

Economic Contributions:

India is home to the second-largest population of goats globally, with approximately 150 million goats (according to the FAO, 2021). Goat farming contributes to about 20% of India's total livestock production. It plays a crucial role in rural economies, especially in semi-arid regions where crop production is less viable. The farming of goats provides a steady source of income through the sale of meat, milk, skin, and manure, serving as a significant economic driver for small and marginal farmers.

Cultural and Nutritional Relevance

Goat farming is not only economically important but also culturally and nutritionally significant. Chevon (goat meat) is a popular dietary staple in India, consumed by millions across the country. Goat milk, rich in essential nutrients, has high demand for both direct consumption and use in making dairy products like cheese. According to the National Dairy Development Board, India produces over 4 million metric tons of goat milk annually, which is crucial for household nutrition and health.

2. How Goat Farming Empowers Small and Marginal Farmers

A Low-Cost Livelihood with High Returns

Goat farming is often termed a "poor man's cow" because it requires low investment in terms of housing, feed, and care compared to other livestock. Goats are highly resilient and can thrive on shrubs and grasses that are naturally available in many rural areas. This resilience makes them an ideal option for small and marginal farmers, who have limited access to fertile land and expensive agricultural inputs. Studies suggest that the profit margins in goat farming can be significant, with minimal inputs required to maintain a productive herd.

Women Empowerment through Goat Farming:

Goat farming has proven to be a vital tool for empowering rural women. In many Indian states, women traditionally rear goats as a secondary source of income, but in recent years, with the help of government schemes and NGOs, goat farming has become a primary occupation for many women. Through cooperatives and Self-Help Groups (SHGs), women are gaining access to credit, technical training, and market linkages. According to a study by Heifer International, women in the states of Rajasthan and Uttar Pradesh who participated in goat farming cooperatives reported a 40% increase in household income, along with enhanced decision-making power in their families.

3. Goat Farming: A Catalyst for Rural Livelihoods and Food Security

Income Diversification for Rural Families:

One of the key benefits of goat farming is that it diversifies the income streams of rural families. Agriculture is often seasonal, and many small farmers are vulnerable to climate-related risks such as droughts or floods. Goat farming, however, can generate income year-round through the sale of milk, kids, and manure. The integration of goat farming into existing agricultural practices also improves resilience, allowing families to have a safety net when crops fail. A study by FAO on livelihood resilience in rural India shows that integrating goat farming increased household income stability by 25%.

Addressing Malnutrition and Improving Food Security:

In rural India, where malnutrition remains a critical issue, goat farming contributes to food security by providing nutritious meat and milk. Goat milk is highly digestible and packed with vitamins and minerals, making it an essential part of diets for many rural families. For landless and marginal farmers, the ability to rear goats provides access to a high-protein diet, thereby helping reduce malnutrition rates among women and children. In regions like Bihar and Jharkhand, where malnutrition rates are high, the introduction of goat farming has been associated with improved nutritional outcomes.

4. Government and NGO Support in Boosting Goat Farming

Government Initiatives:

The Government of India has recognized the potential of goat farming in rural development and has launched several schemes to support goat farmers. The National Livestock Mission (NLM) offers financial assistance for starting and expanding goat farming businesses. Under the Rashtriya Krishi Vikas Yojana (RKVY), goat farmers are provided with subsidies for purchasing quality breeds, setting up infrastructure, and improving feed and healthcare for goats. According to the Ministry of Agriculture and Farmers' Welfare, nearly 1.5 lakh goat farmers benefited from these schemes in 2022 alone.

NGO Support and Capacity Building:

Several NGOs play a pivotal role in promoting goat farming as a tool for rural empowerment. Organizations like Pradan, Heifer International, and Action for Social Advancement (ASA) provide training in sustainable goat farming practices, veterinary care, and cooperative formation. They help establish networks of women-led cooperatives, allowing rural women to share resources, access markets, and improve the quality of their livestock. A case study conducted by Heifer International in Rajasthan found that women involved in goat farming initiatives experienced a 30% increase in income within the first year of joining these programs.

5. Strengthening Market Linkages through Cooperatives

Enhancing Market Access:

One of the biggest challenges faced by rural goat farmers is access to markets. Middlemen often exploit individual farmers by offering low prices for livestock and meat. However, by forming cooperatives, goat farmers are able to pool their resources, collectively bargain for better prices, and directly access larger markets. According to a report by the

Cooperative Development Foundation, cooperative goat farming in Maharashtra enabled farmers to increase their income by 35% by bypassing intermediaries.

Value Addition and Processing:

Through cooperatives, farmers are also engaging in value-added activities such as processing goat milk into cheese, yogurt, and other dairy products. This not only increases the profitability of goat farming but also opens up new avenues for marketing. Goat milk products, especially organic and artisanal items, are gaining popularity in urban markets, providing rural farmers with an opportunity to tap into a higher-value customer base. Pradan's initiative in Madhya Pradesh has successfully linked goat milk producers with urban buyers, increasing revenues by nearly 50%.

6. Case Studies: Real-World Examples of Rural Empowerment through Goat Farming

Case Study 1: Women Goat Farmers in Rajasthan:

In rural Rajasthan, a group of 50 women started a goat farming cooperative with the help of a local NGO. Initially, the women faced difficulties in accessing markets and improving herd quality. However, with technical support and access to microfinance, they were able to increase their herd size, access better healthcare for their goats, and secure higher prices in regional markets. Over the course of five years, their cooperative income tripled, and the women reported improvements in their social status and ability to influence household decisions.

Case Study 2: Goat Farming in Odisha's Tribal Communities:

In Odisha, goat farming has transformed the lives of tribal communities who were traditionally dependent on forest resources. By adopting sustainable goat farming practices, these communities have been able to enhance their income and reduce deforestation. Tribal women, in particular, have taken up goat farming as a primary occupation, resulting in improved household nutrition and increased financial independence.

7. Challenges and Opportunities for Goat Farming in Rural India

Key Challenges:

Despite the success stories, goat farming in India still faces several challenges:

Limited Veterinary Care: Access to veterinary services in rural areas is often inadequate, resulting in high mortality rates among goats, especially in young kids.

Lack of Market Infrastructure: Poor infrastructure, including roads and transportation, limits the ability of farmers to access profitable markets.

Disease Outbreaks: Goats are susceptible to diseases like Peste des petits ruminants (PPR) and brucellosis, which can cause significant losses if not managed effectively.

Future Opportunities:

Organic and Ethical Farming: As consumer preferences shift towards organic and ethically sourced products, small-scale goat farmers can tap into new market segments by adopting sustainable practices.

Technological Innovations: The use of mobile apps for livestock management, market information, and veterinary services can revolutionize goat farming. In states like Maharashtra, digital platforms are already connecting farmers with veterinarians and buyers, increasing efficiency and profits.

Conclusion

Goat farming is a powerful engine of rural empowerment in India. It not only offers a sustainable source of income for marginalized groups but also enhances food security and empowers women. With the right support from government schemes, NGOs, and cooperatives, goat farming can play a pivotal role in alleviating poverty, reducing inequality, and fostering rural development. The future of goat farming in India holds great promise, and by addressing existing challenges, this sector can continue to transform rural lives.

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ROLE OF CYBER SYSTEMS FOR THE DEVELOPMENT OF FARMERS

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Introduction

A cyber system refers to a networked collection of hardware, software, and processes designed to collect, process, store, and exchange data. It includes both physical infrastructure, such as computers, servers, and networking equipment, and digital components like software applications, operating systems, and data communication protocols. It is play a key role in controlling and automating various functions across industries, including business operations, critical infrastructure, and communication networks.

Cyber systems are integral to modern life, encompassing a wide array of technologies, from personal devices and corporate IT systems to critical infrastructure such as power grids, transportation, and telecommunications networks. These systems are often connected via the internet, enabling seamless data flow but also introducing vulnerabilities. Key areas of focus in cyber systems include: 1. Cybersecurity – Ensuring the protection of the system against threats like hacking, viruses, and data breaches. 2. Data Management – Handling large volumes of data efficiently and securely. 3. Network Architecture -Designing and maintaining reliable, scalable, and secure networks. Cyber systems are foundational to the digital economy and are at the heart of advances in smart technologies, IoT (Internet of Things), and cloud computing.

How correlate the cyber systems with the development of rural farmers:

Cyber systems can significantly contribute to the **development of rural farmers** by improving access to critical information, enhancing agricultural practices, and facilitating better market connections. Here's how the correlation works:

Fig.1 Cyber Systems

1. Access to Information and Education

Cyber systems, through internet-based platforms and mobile applications, provide rural farmers with real-time information on:

Weather forecasts: Helping farmers make informed decisions about planting, irrigation, and harvesting.

Pest and disease management: Alert systems can provide early warnings about outbreaks, helping farmers take preventive measures.

Farming best practices: Farmers can access tutorials, guides, and training on-modern farming techniques, improving crop yields and reducing costs.

2. Market Connectivity

Through e-commerce and digital platforms, farmers can:

Reach broader markets: Cyber systems enable farmers to sell their products directly to consumers or retailers, bypassing middlemen, which can result in better prices and higher profits.

Price discovery: Farmers can access current market prices, which allows them to make better decisions about when and where to sell their produce.

Financial inclusion: Digital banking and mobile money services allow farmers to participate in the formal economy, giving them access to loans, insurance, and savings accounts.

3. Precision Agriculture

Cyber systems integrate **IoT sensors, drones, and AI** to help farmers optimize resource use by:

Soil and crop monitoring: IoT sensors can monitor soil moisture, nutrient levels, and crop health, helping farmers make data-driven decisions about irrigation and fertilization.

Yield prediction and crop management: Machine learning algorithms can analyze farm data to predict yields, allowing farmers to plan more effectively.

4. Supply Chain Management

Cyber systems can enhance the supply chain by:

Tracking produce: Blockchain and other technologies can be used to trace the origin of produce, ensuring transparency and enhancing consumer trust.

Reducing post-harvest losses: Data-driven supply chain management helps farmers connect with buyers faster, reducing spoilage and waste.

5. Government and Policy Support

Governments can use cyber systems to**:**

Deliver subsidies and grants: Through digital platforms, governments can provide financial support to farmers more efficiently.

Monitor agricultural trends: Cyber systems enable better data collection and analysis, helping policymakers to design targeted interventions for rural farming communities.

By empowering farmers with technology and digital resources, cyber systems can drive significant economic growth, improve agricultural productivity, and enhance the overall quality of life in rural areas.

Role of cyber system supporting different sectors:

In India, **cyber systems** play a crucial role in supporting various sectors such as governance, defense, banking, healthcare, and critical infrastructure. Their functions include:

1. National Security: Cyber systems are vital for protecting India's critical infrastructure, defense networks, and sensitive government data from cyber-attacks. The National Cyber Security Policy and initiatives by organizations like CERT-IN (Computer Emergency Response Team – India) focus on enhancing national cybersecurity.

2. E-Governance: Cyber systems underpin India's Digital India initiative, enabling e-governance services like Aadhaar, GST, digital payments, and online access to government services, improving transparency and efficiency.

3. Financial Sector: With the rise of digital payments, banking, and financial services rely heavily on secure cyber systems to prevent fraud, ensure data protection, and support a growing digital economy.

4. Public Awareness & Capacity Building: Through training, awareness programs, and skill development initiatives, cyber systems contribute to building a cyber-resilient society, helping citizens stay secure online.

5. Law Enforcement: The role of cyber systems in aiding law enforcement in identifying, tracking, and prosecuting cybercrimes is critical. The IT Act (2000) provides a legal framework for addressing cybercrimes.

6. Critical Infrastructure: Cyber systems safeguard power grids, transportation, and communication networks against potential cyber threats, ensuring the continuity of essential services.

In essence, cyber systems in India form the backbone of its digital infrastructure, safeguarding national interests, promoting digital governance, and enabling economic growth.

Demand of cyber systems in India

The demand for cyber systems in India has grown significantly across various sectors, driven by rapid digitalization, increased internet penetration, and the expanding scope of the digital economy. Key factors contributing to this rising demand include:

1. Digital India Initiative:

The Indian government's Digital India campaign has been a major driver of cyber system demand. It aims to transform the country into a digitally empowered society, leading to increased reliance on cyber infrastructure for services like e-governance, healthcare, education, and digital payments.

2. Rise of Digital Payments:

With the surge in digital payment platforms like UPI (Unified Payments Interface), Paytm, and Google Pay, there is a high demand for robust and secure cyber systems to safeguard financial transactions, ensure data privacy, and prevent cyber fraud. The government's push toward a cashless economy has further accelerated this trend.

3. Cyber security Needs:

India has seen a rise in cyber threats, including hacking, phishing, and ransomware attacks, leading to increased demand for cybersecurity solutions across industries such as banking, defense, healthcare, and e-commerce. This has prompted businesses and governments to invest more in advanced cybersecurity systems and skilled manpower.

4. Growth of E-commerce:

The growth of e-commerce in India, led by platforms like Amazon, Flipkart, and others, has heightened the demand for cyber systems to manage transactions, logistics, customer data, and inventory management, all of which require robust cyber infrastructure.

5. Smart Cities and IoT:

The development of smart cities and the increasing adoption of the Internet of Things (IoT) are driving the demand for cyber systems to manage and analyze large volumes of data from connected devices, smart grids, and urban infrastructure.

6. Remote Work and Cloud Computing:

The shift toward remote work due to the COVID-19 pandemic has increased the demand for cloud computing and cybersecurity systems to ensure the smooth operation of businesses across sectors. Cloud service providers like AWS, Microsoft Azure, and Google Cloud are experiencing high demand as businesses adopt flexible working models.

7. Education and Healthcare:

With the rise of online education and telemedicine, there is growing demand for cyber systems to support virtual learning environments and digital healthcare platforms, ensuring seamless and secure services to students and patients.

8. Agriculture:

Digital agriculture platforms, precision farming, and the rise in mobile and internet usage among farmers have led to increased demand for cyber systems to manage agricultural data, provide weather forecasts, market prices, and access to government schemes.

Role of cyber systems in India for the development of farmers

Cyber systems play a significant role in enhancing the development of farmers in India by improving access to technology, information, and services. Key contributions include:

1. Digital Platforms for Market Access: Cyber systems support platforms like the e-NAM (National Agriculture Market), which allows farmers to sell their produce directly to buyers across India. This reduces the role of middlemen, ensuring better prices and market access.

2. Weather and Crop Advisory: Farmers can access real-time weather forecasts, pest alerts, and crop advisories through mobile apps and SMS services. This helps them make informed decisions regarding sowing, irrigation, and harvesting, reducing losses due to adverse weather conditions.

3. Financial Inclusion and Direct Benefit Transfers (DBT): Cyber systems facilitate financial inclusion for farmers through digital banking and mobile payment solutions. This helps in faster disbursement of subsidies, crop insurance, and other government benefits directly to their bank accounts.

4. Smart Farming and Precision Agriculture: Advanced cyber systems, including IoT (Internet of Things) and satellite imagery, enable precision farming. Farmers can monitor soil health, optimize water usage, and improve yields with data-driven insights.

5. Agricultural Information Portals: Government initiatives like Kisan Suvidha and mKisan provide farmers with easy access to information related to crop prices, farming techniques, and government schemes, helping them adopt better agricultural practices.

6. Capacity Building and Training: Cyber systems enable online training programs and educational resources for farmers to learn modern agricultural techniques and sustainable practices. This helps them increase productivity and profitability.

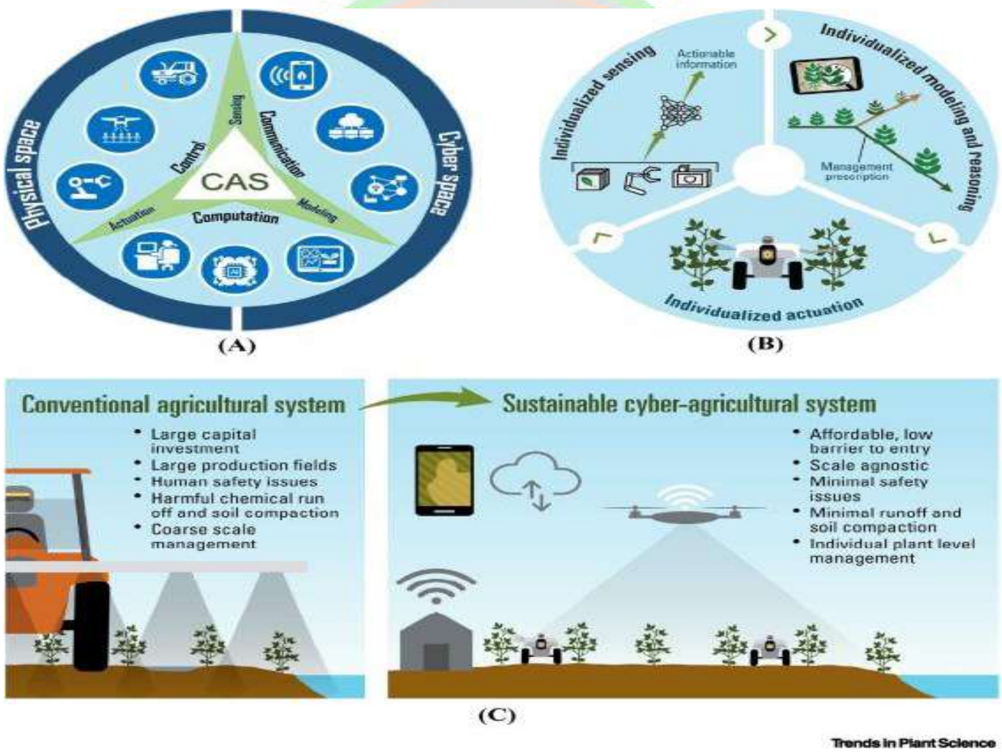

Fig.2 Role of Cyber Systems for the development of Farmers

7. Supply Chain Optimization: Digital platforms improve the supply chain by linking farmers with logistics providers, reducing post-harvest losses and ensuring timely delivery of produce to markets. Cyber systems empower Indian farmers by enhancing their access to critical information, improving market linkages, and supporting financial and technological inclusion, ultimately driving agricultural productivity and income growth.

Conclusion

In summary, cyber systems empower Indian farmers by enhancing their access to critical information, improving market linkages, and supporting financial and technological inclusion, ultimately driving agricultural productivity and income growth.

Cyber systems in Indian agriculture is vast, given the country's large and diverse agricultural sector. By integrating the role of cyber systems in the development of farmers in India is becoming increasingly crucial. Cyber systems, which include technologies like the Internet of Things (IoT), data analytics, mobile apps, and digital platforms, have transformed agricultural practices by providing farmers with real-time data, improved access to markets, and enhanced knowledge of best farming practices. These systems facilitate precision farming, crop monitoring, weather forecasting, and pest control, leading to better productivity and reduced risks. Additionally, government initiatives such as Digital India and Agri-Tech startups are pushing for greater adoption of cyber systems in rural areas, enhancing accessibility for farmers.

However, challenges like digital illiteracy, lack of internet infrastructure in remote areas, and high costs of advanced technologies need to be addressed. With continued efforts in improving digital infrastructure and educating farmers, the cyber system's potential to revolutionize Indian agriculture is immense, offering long-term sustainability and increased economic empowerment for farmers.

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TRANSFORMING SERICULTURE IN JAMMU AND KASHMIR: THE IMPACT OF THE HOLISTIC AGRICULTURE DEVELOPMENT PROGRAMME (HADP)

Article ID: AG-VO4-I10-26

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Abstract

This paper critically examines the transformative role of the Holistic Agriculture Development Programme (HADP) in advancing sericulture practices in Jammu and Kashmir. Through innovative technologies and structured support systems, HADP has significantly contributed to enhancing cocoon production, improving farmer incomes, and preserving the region's cultural heritage. By analyzing various initiatives, this study sheds light on HADP's comprehensive impact on the local economy and silk industry, emphasizing its potential to restore Jammu and Kashmir's reputation as a global silk producer.

Keywords: sericulture, jammu and Kashmir, sustainanability.

1. Introduction

Agriculture and allied sectors significantly contribute over 18% to Jammu and Kashmir's gross domestic product (GDP), amounting to approximately ₹37,600 crores annually, and provide livelihoods to more than 1.3 million families [1]. Historically, these sectors have been the backbone of the rural economy; however, the union territory has predominantly relied on subsistence farming. This approach has led to various challenges, including low productivity, diminishing farmer margins, unsustainability, climate change impacts, and heightened competition from both domestic and international markets [2].

Holistic Agriculture Development Programme (HADP): Formation and Objectives

To address these challenges and establish a technology-driven, sustainable, and profitable agro-economy, the UT Administration constituted an apex committee of experts, led by Dr. Mangala Rai, former Director General of ICAR. This committee's mandate was to identify key intervention areas that would benefit from enhanced policy and capital support. Strategies proposed by the committee for cultivating a robust and commercially viable agricultural landscape include strengthening seed systems, leveraging Jammu and Kashmir's unique geo-climatic advantages, enhancing production and productivity, and monetizing agricultural produce. Additionally, the committee emphasized the importance of promoting secondary agriculture through the establishment of agri-business ecosystems that feature integrated value chains. These initiatives are designed to secure livelihoods by creating jobs and increasing income levels for farmers [3].

The committee submitted comprehensive proposals spanning the major domains of agriculture, such as horticulture, crop production, and livestock husbandry, outlined in 29 specific projects intended to fortify the foundation of Jammu and Kashmir's rural economy. Recently, the Administrative Council, chaired by the Hon'ble Lt Governor, approved these 29 projects with an allocation of ₹5,013 crores over the next five years [4].The implementation of these 29 projects is guided by principles of economy, equity, and ecology, which will fundamentally transform the agricultural landscape of Jammu and Kashmir. These initiatives are projected to nearly double output across sectors, enhance export opportunities, and ensure sustainability and commercial viability. Importantly, these benefits are expected to be distributed equitably, reaching the most disadvantaged individuals within the community while also being ecologically sustainable through efficient utilization of bio-resources for food, feed, and industry [5]. This transformation heralds a new era of farmer prosperity and enhanced rural livelihood security in Jammu and Kashmir, with agricultural output anticipated to rise from ₹37,600 crores to over ₹65,700 crores annually, increasing the sector's growth rate to 11% [2].

The projected interventions will create employment opportunities for approximately 280,000 youth and establish around 19,000 new enterprises. Additionally, more than 250,000 individuals will receive training in various agri-enterprises, including seed production, precision vegetable farming, bee-rearing, cocoon production, mushroom farming, integrated and organic agriculture, high-density fruit farming, processing, dairying, sheep and poultry farming, as well as fodder production [1]. Over the next five years, the union territory aims to develop a motivated workforce equipped with agri-entrepreneurial skills within a commercially viable and ecologically sustainable agri-ecosystem.

This multifaceted initiative aims to modernize agricultural practices, enhance economic conditions, and safeguard cultural heritage, with objectives centered on improving productivity, sustainability, resource availability and market accessibility [6].

HADP project: Technological interventions to strengthen Sericulture in UT of J&K	
1. Silk Industry	✓ Mulberry Plantation and Silkworm Production ✓ Establishment of Silkworm Rearing Centers ✓ Technological Advancements ✓ Financial Assistance and Subsidies ✓ Training and Skill Development ✓ Restoring International Reputation ✓ Application and Process
2. Modernization of Sericulture Practices	✓ Hybrid Silkworms ✓ Training Programs
3. Improved Cocoon Production	✓ Quality Enhancement ✓ Yield Increase
4. Economic Benefits	✓ Increased Farmer Income ✓ Job Creation
5. Revitalization of Traditional Crafts	✓ Integration with Handicrafts ✓ Sustainability
6. Government Support and Infrastructure Development	✓ Silk Production Centers ✓ Market linkages

Table 1: Various objectives of one of the projects for promotion of sericulture in J&K under HADP

A flagship initiative under this program focuses on technological interventions to strengthen sericulture in Jammu and Kashmir, with goals to double silkworm seed and cocoon production, thereby restoring the region's reputation as a producer of high-quality bivoltine silk. This includes planting 1 million mulberry trees and creating a state of the art automatic reeling facility.

Historically, Jammu and Kashmir has been renowned for its high-quality silk production; however, the sector has experienced a decline over the past decade. Issues such as a shortage of quality mulberry leaves, low cocoon yields compared to national averages, inadequate rearing space, and insufficient farmer knowledge have hampered growth. Furthermore, the region is deficient in silkworm seed production and processing facilities (less than 30% capacity).Poor infrastructure has also led to substandard raw silk quality [3].

Key Initiatives to Restore the Silk Industry

Mulberry Plantation and Silkworm Production

A primary goal of the HADP is to mitigate the shortage of mulberry trees essential for silkworm sustenance. The program has initiated the establishment of new plantations throughout the region, thereby ensuring a consistent and adequate food source for silkworms. Furthermore, the production of silkworm eggs (or seeds) is projected to double, significantly augmenting cocoon production [7].

Establishment of Silkworm Rearing Centers:

These centers are designed to be well-equipped, ensuring optimal conditions for silkworm breeding and care, thus marking a significant advancement in modernizing the silk industry within the region [8].

Technological Advancements:

The program's introduction of automatic reeling machines represents a notable technological advancement, streamlining the silk extraction process from cocoons. These machines enhance efficiency and improve the overall quality and quantity of silk production while establishing critical market linkages for silk farmers [9].

Financial Assistance and Subsidies:

Farmers engaged in the HADP will receive financial assistance of ₹70 per mulberry plant, coupled with a substantial 90% subsidy. This financial support aims to alleviate economic burdens on farmers, thereby incentivizing the adoption of enhanced farming practices [6].

Training and Skill Development:

An extensive training initiative is set to benefit over 15,000 farmers, focusing on various aspects of sericulture. This capacity-building effort is designed to ensure the adoption of best practices, enabling farmers to achieve the highest quality production [10].

Restoring International Reputation:

Through these targeted initiatives, the HADP seeks to restore Jammu and Kashmir's international reputation as a premier producer of high-quality silk, a status that the region has historically held [11].

Application and Process:

Farmers interested in participating in the HADP may submit applications through local Sericulture Assistants or District Sericulture Officers. Alternatively, an online dashboard provided by the program allows for digital applications, streamlining the process [12].

Modernization of Sericulture Practices

1) Hybrid Silkworms:

The introduction of hybrid silkworm varieties has markedly enhanced the resilience and productivity of silk farming. These hybrids, being more compatible with local climatic conditions, have resulted in the production of higher-quality cocoons [7].

2) Training Programs:

The HADP has instituted comprehensive training sessions for local farmers, emphasizing scientific sericulture techniques, pest management strategies, and mulberry cultivation methods. This robust approach to capacity building empowers farmers to transition towards modern, efficient practices [10]

Improved Cocoon Production

1. **Quality Enhancement**

   Scientific interventions have significantly improved the quality of cocoons produced, enabling farmers to secure better market prices. The enhanced production capabilities now allow farmers to meet international standards, thereby increasing their competitiveness

2. **Yield Increase**

   Reports indicate that farmers engaged in HADP initiatives have realized substantial increases in cocoon yields, fostering a more resilient silk industry in the region

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Economic Benefits

1) **Increased Farmer Income:**

The modernization of sericulture pratices has led to a notable increase in farmer incomes, with the introduction of higher-quality cocoons allowing them to command better prices in both local and national markets [12].

2) **Job Creation:**

The expansion of the sericulture sector has catalyzed job creation in related areas, such as silk processing and weaving, thus providing new employment opportunities in rural areas [7].

Revitalization of Traditional Crafts

1) **Integration with Handicrafts:**

The HADP promotes the incorporation of locally produced silk into traditional handicrafts, which supports artisans and preserves cultural practices. This initiative has led to a renewed interest in silk weaving and craftsmanship, revitalizing traditional art forms [11].

2) **Sustainability:**

The program advocates for sustainable practices in sericulture, assisting farmers in reducing reliance on chemical inputs and endorsing environmentally friendly cultivation methods [9].

Government Support and Infrastructure Development

1) **Silk Production Centers:**

The establishment of dedicated silk production centers has improved access to quality silkworms, training, and essential resources for local farmers, thereby bolstering the silk industry

2) **Market Linkages:**

The HADP has successfully established connections between farmers and markets, ensuring fair pricing and enhancing the visibility of locally produced silk, further supporting the economic landscape (12).

Conclusion

The success stories emanating from the Handloom and Handicraft Development Programme highlight its transformative impact on sericulture within Jammu and Kashmir. By modernizing practices, enhancing cocoon quality, and increasing farmer incomes, the HADP has effectively revitalized the silk industry while simultaneously preserving the region's rich cultural heritage. Through targeted initiatives such as improved mulberry cultivation, the establishment of rearing centers, and the provision of financial assistance, the program is poised to yield significant economic benefits and reestablish Jammu and Kashmir as a leading producer of silk on the global stage (13,14)

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ADVANCED APPLICATIONS OF NANOTECHNOLOGY IN SERICULTURE, SILKWORMS AND MORICULTURE: A TECHNICAL REVIEW

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Abstract

Nanotechnology, an advanced scientific frontier, has revolutionized various sectors, including sericulture and moriculture. The integration of nanotechnology into sericulture and moriculture presents a groundbreaking opportunity to address the longstanding challenges of the silk industry, including low yields, disease outbreaks, and environmental sustainability. Traditional silk production methods often depend on chemical inputs that pose ecological risks and limit productivity. Nanoparticles, such as nanofertilizers, enhance nutrient absorption in mulberry cultivation, while nanopesticides offer targeted pest control, reducing harmful impacts on the environment. Additionally, the use of nanomedicine strengthens silkworm immunity against diseases, contributing to healthier populations and higher-quality silk. Incorporating nanomaterials into silk fibers enhances their mechanical properties and functionality, such as UV resistance. Overall, the adoption of nanotechnology in sericulture fosters sustainable practices, leading to improved efficiency and productivity in the silk industry. This paper explores these applications and their implications for the future of sericulture.

Keywords: nanotechnology, sericulture, nanofertilizers, nanopesticides, nanomedicine.

Introduction

Sericulture or silk farming, has played a crucial role in the economies of several Asian countries for millennia. However, traditional sericulture faces significant challenges such as low yield, disease outbreaks and environmental concerns from excessive chemical use in mulberry cultivation. The introduction of nanotechnology into sericulture, silkworm rearing and moriculture has the potential to overcome these limitations, leading to a more efficient, sustainable and productive silk industry (1).

Nanotechnology, defined as the manipulation of matter on an atomic and molecular scale, involves particles between 1 and 100 nanometers in size. These nanoparticles have unique physical, chemical, and biological properties that differ from bulk materials, allowing for applications across various fields, including medicine, electronics, and agriculture [(2)].

In sericulture and moriculture, nanotechnology is being applied in several key areas:

i. **Nanofertilizers**: Enhance nutrient absorption in mulberry plants [(3)].

ii. **Nanopesticides**: Offer precision pest control, reducing environmental damage [(4)].

iii. **Nanomedicine**: Helps improve silkworm immunity and mitigate viral or bacterial diseases [(5)].

iv. **Nanomaterials**: Incorporated into silk fibers to improve their mechanical and functional properties [(6)].

How Nanotechnology Works?

The integration of nanotechnology into the sericulture process represents a transformative approach to silk production, enhancing efficiency and sustainability. Below is an elaboration of each step outlined in the simplified flowchart:

a) **Nanoparticle Synthesis:** Metal, carbon, and organic nanoparticles are synthesized using chemical, physical or biological methods [(7)].

b) **Application in Moriculture:** Nanofertilizers are applied to enhance mulberry plant growth. Nanopesticides provide targeted pest control with minimal environmental impact [(8)].

c) **Integration in Silkworm Diet:** Nanoparticles like nanochitosan or nanosilver are added to silkworm feed to boost immunity and growth [(9)].

d) **Nanomaterials in Silk Fibers:** Nanoparticles such as TiO2 or carbon nanotubes are incorporated into silk fibers, enhancing strength, flexibility and UV resistance [(1)].

e) **Enhanced Silk Yield and Quality:** The use of nanotechnology results in healthier silkworms and higher-quality silk with improved mechanical properties [(2)].

2. Nanotechnology in Sericulture

2.1. Enhancing Silk Properties with Nanomaterials

Nanotechnology has enabled unprecedented improvements in silk's mechanical and functional properties. Nanoparticles like TiO2, ZnO and silver nanoparticles (AgNPs) have been used to enhance silk fibers. These nanoparticles increase silk's UV resistance, antimicrobial qualities, and tensile strength [(10)]. For instance, TiO2 nanoparticles create a protective layer on silk that blocks harmful UV rays, increasing durability. Additionally, carbon nanotubes (CNTs), when incorporated into the silk matrix, enhance the fiber's strength and flexibility, making silk suitable for high-performance and medical textiles [(11)].

Incorporating nanoparticles into silk fibers can modify their physical properties, enhancing strength, flexibility, and antimicrobial characteristics [(5)]. Nanoparticles can be integrated to create smart silk textiles that respond to environmental stimuli, offering applications in high-tech fashion and protective clothing.

2.2. Nanoparticle Enriched Silkworm Diets

Nanotechnology also impacts silkworm physiology directly. Supplementing silkworm diets with nanochitosan, nanosilver, and silicon nanoparticles enhances growth rates and silk yield [(12)]. Research has demonstrated that nanochitosan improves digestion and nutrient absorption, resulting in larger and more robust cocoons. Carbon-based nanomaterials like graphene have been tested as supplements to increase silk's conductivity, opening new applications in smart textiles and bioelectronics [(11)].

Nanoparticles can encapsulate essential nutrients, vitamins, and minerals, facilitating efficient delivery to silkworms through their feed. This targeted approach ensures optimal nutrient absorption, enhancing growth rates and silk quality [(3)]. Nanoparticles can also be engineered to deliver specific amino acids and growth hormones that are crucial for silkworm development, helping optimize growth conditions and promote faster silk production.

3. Nanotechnology in Moriculture

3.1. Nanofertilizers for Improved Mulberry Cultivation

Nanofertilizers represent a breakthrough in moriculture by increasing nutrient efficiency. Traditional fertilizers suffer from leaching, leading to soil degradation and reduced nutrient availability. In contrast, nanofertilizers like nanosilica and nano-hydroxyapatite release nutrients gradually, ensuring better nutrient uptake by mulberry plants. Studies show that nanofertilizers improve leaf quality, which directly affects silkworm health and silk output [(13)]. Improved nutrient availability fosters better mulberry growth, which enhances the overall productivity of sericulture.

3.2. Nanopesticides for Pest Control

Pests such as whiteflies, mealybugs, and leafhoppers severely impact mulberry leaves, causing significant losses. Conventional pesticides not only harm non-target organisms but also lead to pest resistance. Nanopesticides, such as those formulated with nanosilver and nanogold, provide a more targeted approach. These nanoparticles penetrate pest cells and disrupt their internal processes without affecting the surrounding flora and fauna. Copper oxide nanoparticles (CuONPs) have shown significant potential in protecting mulberry crops by reducing the need for repeated pesticide applications [14].

Nanoparticles can be formulated into eco-friendly insect repellents that protect mulberry plants from pests [4]. Nano-encapsulated plant extracts can enhance the efficacy of natural insect repellents, ensuring prolonged protection against pests while being environmentally friendly.

4. Disease Management in Silkworms Using Nanotechnology

4.1. Nanosilver for Bacterial Infections

Silkworms are susceptible to bacterial diseases such as flacherie and septicemia, which can decimate silk production. Nanosilver has been identified as an effective antibacterial agent. When used in silkworm rearing facilities, nanosilver helps control the spread of bacterial infections, significantly reducing silkworm mortality rates. Nanosilver's bactericidal properties stem from its ability to disrupt bacterial cell membranes, preventing bacterial growth in silkworm populations [15].

Nanosensors have been developed for the rapid detection of pathogens in silkworm populations. These sensors can identify specific diseases at very low concentrations, allowing for timely interventions [8]. Nanoparticles can be functionalized with antibodies specific to silkworm pathogens, enabling targeted treatment and reducing the overall chemical load in the environment.

4.2. Nanovaccines for Viral Disease Control

Nanotechnology also plays a critical role in combating viral diseases like grasserie (caused by *Bombyx mori* nucleopolyhedrovirus), which can cause widespread damage in sericulture. Nanovaccines, which deliver viral antigens via nanoparticles, are a novel approach to silkworm immunization. These vaccines enhance the immune response and offer long-lasting protection against viral infections [16]. Nanovaccines are particularly effective due to their ability to target specific cells, ensuring that the viral load in silkworms is controlled more effectively than traditional vaccines.

5. Environmental Sustainability in Sericulture

Nanotechnology not only boosts productivity but also offers environmentally sustainable alternatives to conventional methods. Nanofertilizers reduce nutrient leaching, and nanopesticides minimize the harmful effects of chemical pesticides. Furthermore, by enhancing disease resistance in silkworms, nanotechnology reduces the need for antibiotics and other harmful treatments, promoting a healthier and more sustainable sericulture ecosystem [13]. Additionally, researchers are exploring green nanotechnology, where biocompatible and biodegradable nanoparticles are used to mitigate environmental risks [17].

Nanoparticles can facilitate the biodegradation of organic waste generated in sericulture. For instance, nano-biocatalysts can be employed to accelerate the breakdown of organic matter [18]. Nanoparticles can also improve composting processes in sericulture by accelerating the decomposition of organic waste, enhancing soil fertility and promoting sustainable practices.

6. Challenges and Future Prospects

While nanotechnology holds great potential in sericulture, several challenges remain. The high cost of nanomaterial production and concerns about the long-term effects of nanoparticles on the environment and human health are significant obstacles [19]. However, advancements in green nanotechnology and cost-effective nanoparticle synthesis are expected to mitigate these issues. Future research should focus on understanding the ecological impact of nanoparticles in sericulture and moriculture, and on developing scalable solutions for widespread adoption.

7. Conclusion

In conclusion, the integration of nanotechnology into sericulture and moriculture represents a transformative approach to overcoming the challenges that have historically plagued the silk industry. The application of nanofertilizers enhances nutrient absorption in mulberry plants, while nanopesticides provide precise pest control, thus minimizing environmental damage. Furthermore, advancements in nanomedicine offer significant improvements in silkworm health by bolstering their immune systems against various diseases.

The incorporation of nanomaterials into silk fibers not only enhances their mechanical properties but also increases their functionality, leading to silk products that are stronger and more durable. These innovations are crucial for promoting sustainability, as they reduce the dependency on harmful chemical inputs, thereby preserving the ecological balance. Moreover, the successful application of nanotechnology in sericulture could serve as a model for other agricultural sectors facing similar challenges, paving the way for broader adoption of nanotechnology across various crops and livestock. As the silk industry continues to evolve, embracing these advancements will be essential for ensuring a resilient and productive future.

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AGRONOMIC PACKAGES OF COCONUT NURSERY AND PLANTATION ESTABLISHMENT

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Introduction

The coconut tree (*Cocos nucifera*) is a member of the palm tree family (Arecaceae) and the only living species of the genus *Cocos*. The term "coconut" (or the archaic "cocoanut") can refer to the whole coconut palm, the seed, or the fruit, which botanically is a drupe, not a nut. *Cocos nucifera* is a large palm, growing up to 30 metres (100 feet) tall, with pinnate leaves 4–6 m (13–20 ft) long, and pinnae 60–90 centimetres (2–3 ft) long; old leaves break away cleanly, leaving the trunk smooth. On fertile natural soil, a tall coconut palm tree can yield up to 75 fruits per year, but more often yields less than 30. Given proper care and growing conditions, coconut palms produce their first fruit in six to ten years, taking 15 to 20 years to reach peak production.

The coconut palm is referred to as 'Kalpavriksha' – the '*tree of heaven*' as each and every part of the palm is useful in one way or the other. Ten million people in India depend on coconut for their livelihood either directly or indirectly. India ranks third in area and first in production of coconut in the world. As per the latest statistics available (2016-17), the annual coconut production in India is 23.90 billion nuts from an area of 2.08 million ha with an average productivity of 11481 nuts/ha. The four southern states *viz.*, Kerala, Tamil Nadu, Karnataka and Andhra Pradesh are the major coconut producing states in India, accounting for more than 90 per cent of the area and production. It has been demonstrated that a four-fold increase in yield (150 nuts/year/tree) can be achieved by adopting scientific technologies in coconut cultivation as compared to the unscientific practices. Thus, there is great scope for enhancing the productivity of coconut through adoption of scientific cultivation technologies.

Nursery agro-techniques

Selection of seed nuts and seedlings are very important in coconut cultivation as the performance of the new progeny can be known only several years after planting. If the seed nuts and seedlings happen to be of poor quality, the new plantation will be low yielding and uneconomic, causing considerable loss of time and money to the grower. The fact that, coconut is a cross-pollinated palm and it does not breed true, makes the selection of seed nuts and then of seedlings in the nursery all the more important. By means of a series of selections made at different stages, it is possible to eliminate poor quality seed nuts and seedlings.

Mother palm selection

In tall varieties, seed nuts should be collected from mother palms which should have attained an age of 20 years. Wherever possible, it is advisable to select middle-aged trees as they will be in their prime of life and it is easier to spot good yielder from mediocre/poor yielder. The important features are: a) straight stout trunk with even growth and closely spaced leaf scars, b) spherical or semi-spherical crown with short fronds, c) short and stout bunch stalks without tendency drooping, d) more than 30 leaves and 12 inflorescences carried evenly on the crown, e) inflorescence with 25 or more female flowers, f) consistent yield of about 80 nuts under rainfed conditions and 125 nuts under irrigated conditions, g) 150 g per palm copra per nut and h) absence of disease and pest incidence. In dwarf varieties, seed nuts can be collected from mother palms which have attained an age of 12 years or more and yielding more than 60 and 100 nuts per year under rainfed and irrigated condition, respectively. Further, it should have a minimum of 30 leaves with a nut weight more than 400 g.

Collection of seed nuts

Seed nuts can be collected throughout the year. However, it is preferable to collect seed nuts during the period from January to May in the West Coast region, so that sowing can be taken up with the onset of south-west monsoon. In the East Coast region, seed nuts are collected during the period from May to September and are sown during October–November with the onset of north-east monsoon. Fully matured nuts *i.e.* about 12 months old should be harvested. Care should be taken not to damage the seed nuts while harvesting. Nuts which are too big or too small in the bunch and also the nuts of irregular shape and size should be discarded. Seed nuts of tall varieties are to be sown 2-3 months after collection, whereas dwarfs should be sown within 15-30 days after harvest.

Raising nursery

Well-drained, coarse-textured soil near dependable irrigation water source should be selected for raising the nursery. The seed nuts can be sown in flat beds if there is no drainage problem. The seeds are to be sown in raised beds, if water stagnation is a problem. Nursery can be raised either in the open with artificial shade or in gardens where the palms are tall and the ground is not completely shaded. The seed nuts should be sown in long and narrow beds at a spacing of 40 cm x 30 cm during May-June, either vertically or horizontally in 20-25 cm deep trenches. Advantage of Vertical planting cause less damage during transit of seedling. However, in delayed planting, when the nut water goes down considerably, adopt horizontal sowing it is good to go for horizontal sowing of seed nuts for better germination.


Selection of seedlings

Only good quality seedlings are to be selected from the nursery for field planting. In tall varieties, vigorous seedlings which are one year old, more than 100 cm in height with 5-6 leaves and girth of 10 cm at the collar should be Seedlings in the nursery selected for planting. In dwarf varieties, the girth and height of good quality seedlings should be more than 8 cm and 80 cm, respectively. Early splitting of leaves is another character preferred for selecting good seedlings. Generally, one year old seedlings are preferable for planting. However, for planting in water-logged areas, 1½ to 2 years old seedlings are to be preferred.

Polybag nursery

Good quality seedlings can be raised in polybags. Germinated seeds can be transplanted in polybags (500 gauge thickness) of 45 cm x 60 cm dimension with 8-10 holes at the bottom.

The commonly recommended potting media are top fertile soil mixed with sand (3:1) or top fertile soil, sand or coir dust and well rotten and powdered cattle manure (3:1:1). Potting mixture containing sand + vermicompost (3:1) is also ideal for raising polybag seedlings. Recent studies show that coir pith can also be used as potting mixture. Application of 25 g each of biofertilisers such as *Azospirillum* spp. and Phosphobacterium *Bacillus* sp., to the polybags results in production of vigorous seedlings. Use of Plant Growth Promoting Rhizobacteria (PGPR) based bioinoculants, '*Kera Probio*', (talc formulation of *Bacillus megaterium*) @ 25 g/seedling and '*Ker*AM' (Arbuscular Mycorrhizal bioinoculant) @ 50 g/seedling also helps in producing robust coconut seedlings. The advantage of polybag seedlings is that, there is no transplanting shock since the entire ball of earth with the root system can be placed in the pits and the seedlings establish early and more vigorously. But the disadvantages include difficulty for transportation and higher cost of seedling production. Care should be taken not to throw away the polybags in the coconut plantation.

Plantation Establishment

Coconut palms flourish best close to the sea on low-lying areas a few feet above high water where there is circulating groundwater and enough rainfall. Most of the world's coconuts are produced on small plantations. Propagation is by unhusked ripe nuts. These are laid on their sides close together in nursery beds and almost covered with soil.

After 4 to 10 months the seedlings are transplanted to the field, where they are spaced at distances of 8–10 meters (26–33 feet). Palms usually start bearing after 5 to 6 years. Full bearing is obtained in 15 years. Fruits require a year to ripen; the annual yield per tree may reach 100, but 50 is considered good. Yields continue profitably until trees are about 50 years old.

Selection of the site

Soils with a minimum depth of 1.2 m (3 feet) and good water holding capacity are preferred for coconut cultivation. Shallow soils with underlying hard rock, low lying areas subject to water stagnation and clayey soils with impeded drainage are to be avoided. However, in lands reclaimed by heaping alternate layers of sand and clay, coconut thrives well. Proper supply of moisture either through evenly distributed rainfall or irrigation and proper drainage are essential for coconut.

Preparation of land and planting

Preparation of land for planting coconut depends to a large extent on soil type and environmental factors. If the land is uneven and full of shrubs, the shrubs have to be cleared and land should be leveled before digging pits. The depth of pits will depend upon the type of soil. In laterite soil with rocky substratum, deeper and wider pits, 1.5 m length x 1.5 m breadth x 1.2 m depth may be dug and filled up with loose soil, powdered cow dung and ash up to a depth of 60 cm before planting. In case of laterite soil, application of 2 kg of common salt will help in loosening the soil. In loamy soils with low water table, planting in pits of 1 m x 1 m x 1 m filled with top soil to height of 50 cm is generally recommended. The coconut seedlings are planted in the centre of the pit by making small hole within the pits and the soil around the seedlings must be firmly pressed, but soil should not be allowed to bury the collar region of the seedling or enter into the leaf axils.

However, when the water table is high, planting at the surface or even on mounds may be necessary. While planting on the surface or mounds also, digging pits and soil filling has to be done. While filling the pits with soil, it is advisable to use top soil. Two layers of coconut husk (with concave surface facing up) can be arranged at the bottom of the pit before filling up. This will help in conserving the moisture. The seedlings, after field planting, are to be protected from heavy wind by staking and from sunlight by proper shading using plaited coconut leaves or palmyrah leaves or any other suitable shading materials.

Underplanting

Generally underplanting is done in plantations where the palms have become unproductive and uneconomic to the farmer. Old palms are removed in stages over a period of 3 to 4 years. First the area to be underplanted is peg marked. To start with, very poor yielders (less than 20 nuts per palm per year) and those trees which are very close to the peg marked point for underplanting are to be removed. Other trees are to be removed at the rate of one third each year during 2nd, 3rd and 4th year after underplanting. If the existing garden is irregularly spaced, old palms within 1 m radial distance from the newly planted seedlings are to be removed in the first year of underplanting, 2 m distance in the second year, 3 m distance in the third year and the rest in the fourth year.

Spacing

For realizing better yield from coconut, optimum plant density must be maintained in the field. A spacing of 7.5 m x 7.5 m to 8.0 m x 8.0 m in the square system is generally recommended for coconut. This will accommodate 177 and 156 palms per ha, respectively. If the triangular system is adopted, an additional 25 palms can be planted. Hedge system can also be adopted giving a spacing of 6.5 m along the rows and 9.5 m between rows. For facilitating multiple cropping in coconut gardens, it is advisable to go for wider spacing of 10 m x 10 m so as to provide more opportunity to accommodate a number of perennial and annual crops in the interspaces.

Time of planting

In well drained soils, seedlings can be transplanted with the onset of south-west monsoon during June or with the onset of north-east monsoon during October-November. In low lying areas subject to inundation during monsoon periods, it is preferable to plant the seedlings after the cessation of the monsoon.

Management of juvenile palms

Adequate care should be taken during the early years of growth of young palms for realizing high yield. The field planted seedlings should be shaded and irrigated adequately during the summer months. Irrigation with 65 litres of water once in 4 days has been found satisfactory in all soil types. If it is drip irrigation, daily 15 litres of water need to be provided. Provision of proper drainage is important in areas prone to water logging. The pits should be cleared of weeds periodically. Soil washed down and covering the collar region of the seedlings during the rainy days should also be removed. The pits should be widened every year before the application of manure. The pits should be gradually filled up as the seedlings grow. By fourth year, the basin should be fully prepared to a radius of 1.8 m from the trunk. The palms should be frequently examined for any insect or fungal attack and necessary remedial measures should be taken up promptly.

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AQUATIC INSECT PESTS: CONTROL STRATEGIES

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Abstract

Aquatic insects play a crucial role in maintaining the balance of healthy aquatic ecosystems. However, in nursery ponds, especially after rainfall, many aquatic insects prey on carp spawn and fry, impacting fish populations. In freshwater ecosystems, insects are the most diverse group, with species such as dragonfly nymphs, *Ranatra* (water stick), *Gerris* (water spider), *Corixa*, *Cybister* (diving beetle), *Notonecta* (back swimmer) and *Belostoma* (giant water bug) posing a threat. These insects are typically caught using fine mesh nets and controlled using substances like kerosene and diesel.

Keywords: Aquatic insects, Pest management, Pest control.

Introduction

Insects are a highly diverse group in freshwater environments, making a significant contribution to aquatic ecosystems. Besides their ecosystem functions, aquatic insects are reliable indicators of human impacts on freshwater systems. In aquaculture ponds, particularly in northwest Bangladesh, non-predatory carp culture and intensive feeding create conditions that allow aquatic insect populations to thrive. Studies have shown that insect populations are higher in ponds than in lakes, with more diversity observed in ponds with moderate aquatic vegetation. The abundance of aquatic insects tends to increase during and after the rainy season.

Impact of Aquatic Insects on Fish Larvae

Aquatic insects such as dragonfly nymphs, backswimmers, and water scorpions pose a significant threat to fish larvae by preying on them and competing for food. Fry mortality is particularly high during early rearing stages in aquaculture nurseries. Factors such as poor water quality, overstocking, and limited food availability contribute to low survival rates of carp spawn.

Development of Aquatic Insects

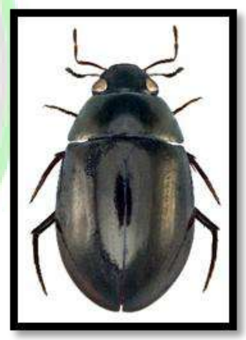
Aquatic insects are integral to aquatic ecosystems and are used as indicators of ecosystem health. Excess organic matter and aquatic weeds promote the growth of these insects. In aquaculture, heavy fertilization of nursery ponds can result in the proliferation of predatory insects, especially during the rainy season in tropical climates.

Effect of Insects on Fish Larval Rearing

Aquatic insects exhibit various feeding habits, with many preying on fish spawn. Dragonfly nymphs are particularly dangerous, with a 15-mm nymph capable of consuming seven carp spawn within three hours. Predatory beetles such as *Cybister* spp. and *Sternolophus* spp. and bugs including the giant water bug (*Belostoma indicum*), water scorpions (*Laccotrephes* spp.) and backswimmers (*Anisops* spp.) also pose a significant threat to carp fry by preying on their body fluids.

Cybister sugillatus

Sternolophus inconspicuous



Belostoma indicum

Laccotrephes spp.

Anisops spp.

Control Measures for Aquatic Insects

Selective insecticides are necessary to target aquatic insects without harming beneficial organisms. A method involves mixing mustard oil and soap in a 56:18 kg/ha ratio for controlling predatory insects in nursery ponds. This treatment kills surface breathers while sparing gill breathers. Other control measures include regular netting with fine mesh and the application of suitable insecticides and soap oil emulsions to maintain a healthy nursery environment.

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UNEXPLOITED LEGUME CROP HORSE GRAM: POTENTIALLY CLIMATE RESILIENT CROP WITH NUTRACEUTICAL BENEFITS

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Introduction

Horse gram is an important minor legume crop grown in semi -arid condition. They are highly tolerant to drought and salinity. Mostly they are grown in marginal land with low inputs under stress condition. In southern part of India, they are cultivated in poor soil under low rainfall condition. It is generally regarded as poor man's pulse crop. It is multipurpose crop used as food, feed, forage and green manure. Presently, attention towards underutilized legumes is increasing for finding new alternate protein sources to meet the ever-increasing demand for vegetable protein (Pugalenthi et al., 2005). It also possesses nutraceutical benefits. They are rich phosphorus, vitamins, amino acid, micronutrients, antioxidants, dietary fibre and low in sodium and lipid content. Owing to increase nutritional and medicinal value, there is an increased demand to explore an underutilized legume (Chel-Guerrero *et al.,* 2002) However, they too have anti nutrient factor like phytate, tannins and trypsin inhibitor.

Horse gram a minor legume crop but climate resilient crop ensuring global food security

Horse gram possess high antioxidant and osmotic adjustment with more efficiency, so that it can be easily cultivated in marginal land with low input. They are rich in dietary protein. Since it is legume crop help to fix soil nitrogen leading to increase in fertility. Horse gram has ability to survive in drought and salinity and adapted to wide range of environment. These features make it as perfect crop for global uncertainty.

Under utilized legume with nutraceutical benefits

According to Messina (1999), pulse crop is excellent source for protein, dietary fiber, micronutrients and phytochemicals. In addition to nutrients, it can also supply many bioactive substances in small quantities which have significant metabolic and/or physiological effects. These compounds contain potential medicinal/nutraceutical properties and have inhibitory role in reduction of various diseases like, coronary heart diseases, diabetes, and obesity (Bazzano *et al.* 2001).

Horse gram is rich in dietary protein (17.9 – 25.3 per cent) which maximum than kidney bean black gram and pigeon pea (Patil and Deshmukh, 1985). According to Mandle *etal.*, (2012), Horse gram exhibit high dietary fibre than all other legume crop excluding chick pea. This crop has a good source of carbohydrate (51.9 – 60.9 per cent) exhibiting more than chickpea, faba bean, mung bean and lentil (Jogyabathi *et al.* 2001). They have profound amount of lipid (0.58 – 2.06 per cent) with iron and molybdenum. As per human consumption they are used as seed and sprouts again seed is also used as cattle feed. Act as excellent source of carotene, thiamine, riboflavin, niacin and vitamin C.

It shows antihyper glycemic property and releases glucose slowly. The alpha amylase extracted from seed has antidiabetic effect. Richness in bioactive compounds like polyphenols, protein, phytic acid, flavonoids, saponins, isoflavones and lignans cause an anti-oxidant and anti-carcinogenic effect. Ferulic acid from seed extract protects against hyper lipidemia and cardiac abnormalities. Litholytic property in horse gram reduces kidney stone. Phytochemical in them produces anti-microbial property. As result, this crop has many unique medicinal properties which makes it more unique than all others legumes.

Antinutritional factors of horse gram

Major drawback in most of the pulse crop is presence of several antinutritional factors which reduces the bioavailability of nutrient (Jain *et al*., 2009). Horse gram flour contains trypsin inhibitor activity (9246±18 TIU/g), phytic acid (10.2±0.4mg/g), polyphenols (14.3±0.4mgGA/g) and oligosaccharides (26.8mg/g) (Sreerama et al., 2012). Due to presence of high level of antinutritional factors (enzyme inhibitors, haemagglutinin activities, oligosaccharides, tannins, polyphenols and phytic acid) than other legume utilization of horse gram as human food is restricted. Conventional processing methods such as dehusking, germination, cooking, and roasting have been shown to produce beneficial effects by decreasing the content of undesirable components which results in enhanced acceptability and nutritional quality in addition to optimal utilization of horse gram as human food (Kadam and Salunkhe, 1985).

Conclusion

- It is an important climate- smart grain legume, adaptive to extreme weather condition and resilient to various biotic and abiotic stresses
- So, this crop valuable genome suitable as alternative in present change
- Horse gram has many therapeutic and bio active compounds along with profound nutritional quality, thereby this can be used in diet on regular basis
- Furthermore, there are still great possibilities exist for this legume to be explored for its chemo-profile, pharmacology, biological evaluation, toxicological consequences, innate health promoting aspects and many undiscovered phytochemicals as well as there is need to promote and support the initiatives that make the most use of this indigenous underutilized legume to address food and nutritional security issues.

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IMPACT OF RANCIDITY IN NUTRITIONAL PROFILE OF PEARL MILLET FLOUR (PENNISETUM GLAUCUM (L.) R.BR.)

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Introduction

Pearl millet is the 6th most important crop worldwide and most imperative crop after rice, wheat and maize in India. It can be grown in marginal and adverse agro-ecological environments, where the survival rate of other crops is very low; hence pearl millet is define as a climate resilient crop. It has a strong nutritional background in term of minerals density, protein and carbohydrates profile and termed as a Nutri-cereal. It also yields high biomass, so it is a good source of forage, stover and feed. It is one of the most preferred cereal crops for poor and marginal farmers. However, apart from all these qualities, it is associated with one drawback that is rancidity of its flour in few hours to few days after milling at room temperature and relative humidity. Rancidity causes the mousy odour and off taste, which is not eatable by the human beings and consumption of rancid flour can causes the serious health issues.

Rancidity

Rancidity word was derived from latin word rancidus which means stinking. It is a biochemical process of fat with oxygen, which converts the long chain fatty acid into the short chain compounds, as a resultant butyric acid is formed, which imparts rancid taste in food. The process of decomposition of lipid, oil and fats either by hydrolysis or oxidation is called rancidification. It is one of the most vital parameter in order to check the quality of pearl millet flour.

Affecting factors of rancidity in pearl millet

There are many reasons for rancidity development in pearl millet, which are oxidation of unsaturated fatty acid, high peroxide activity, enzymatic modifications in C-glycosylflavones, presence of phenolics in meal and their enzymatic degradation. While C-glycosylflavones and phenolics have no ability to produce rancidity without peroxidase and lipase activity.

High fat content:

Pearl millet grains contain approximately 7 to 7.9% of fat content and mostly abundant with unsaturated fatty acids like oleic (C18:1), linoleic (C18:2) and linolenic (C18:3) and also contain small amount of saturated fatty acids such as palmitic (C16:0) and stearic (C18:0). High triglycerides profile of pearl millet grain is the main reason for its deterioration by lipolysis and oxidation processes. While unsaturated fatty acids concentration is very high in pearl millet grain and get readily oxidise from surrounding oxygen and moisture which produce unpleasant taste in its flour.

Lipase activity

Lipase enzyme or triacylglycerol acylhydrolase is intensed in the pericarp, aleurone layer and germ of pearl millet grain. Lipase convert the complex form of triacylglycerol to simple form and also release free fatty acid and glycerol.

$$\text{Triacylglycerol} + 3H_2O \underset{\text{lipase}}{\Longleftrightarrow} \text{Glycerol} + 3 \text{ fatty Acid}$$

Peroxidase:

Peroxidase causes the rancidification of pearl millet flour through oxidation.

$$\text{Electron donor} + H_2O_2 \xrightarrow[\text{Peroxidase}]{} \text{Oxidised electron donor} + 2H_2O$$

C-glycosylflavones

C-glycosylflavones is a class of flavonoids which includes Glucosylvitexin, glucosylorientin and vitexin. Reichert (1979) acknowledged C-glycosylflavones viz., glucosylvitexin, glucosylorientin and vitexin that were 3-pH-sensitive pigments. The concentration of C-glycosylflavones was 124 mg/100 g in pearl millet grain and outer layers was much dense with C-glycosylflavones as compared to inner portion of the seeds reported by Reichert and co-workers (1980). Reddy et al. (1986) identified these compounds as the agents which produce unpleasant odour in ground pearl millet.

Oxygen concentration:

The oxygen availability is an imperative factor for rancidity as oxidation process is carried out in presence of oxygen (Berger, 1994).

Effect of temperature:

Temperature influences on shelf life of cereals grain. The rate of reaction of oxygen with fats is increase as the temperature increase (Berger, 1994).

Effect of light:

Light is also a rancidity promoting factor as oxidation of fat is increased in presence of light through photo-oxidation (Hamilton, 1994). The oxidation process through photosensitisation involves substrate activation, which consequently reacts with unsaturated fatty acids (W¹sowicz E et al., 2004).

Although pearl millet has strong nutritional background but its utilization becomes limited because of some obstacle like undesirable colour of its flour and products and also unpleasant odour in its flour during storage. Pearl millet flour has very short life, as it rapidly gets rancid, that produces off odour in its flour and cooked products. Pearl millet is a staple food in many states like Rajasthan, Haryana and Uttar Pradesh in India. Rural peoples of such regions have mainly depends on it for their daily energy requirements and household women pound it into flour traditionally, but only few days requirement can be completed as rancidity destroys its quality. Commercialization of pearl millet flour is also very less because of rapid rancidity.

Indicators of rancidity:

Some parameters can be used to identify the rancidity level in pearl millet flour are as follows:

Acidity of fat:

Acidity of fat is a perceptive and imperative parameter to find out the product quality of cereals. It can be a marker of biochemical changes during storage of cereal and its product. Acid value (AV) or free fatty acid (FFA):

The acid value (AV) is a common and important factor for the measurement of fats and oils. It estimates the quantity of KOH (in mg) required to neutralize the organic acids of fat (one gram) and also estimation of free fatty acids (FFA) in fat and oil.

Peroxide value (PV):

A peroxide value indicates the oxidation or hydrolysis of unsaturated fats and oils. Auto-oxidation is the process of free radical reaction with oxygen that occurs most commonly in unsaturated fatty acids which can be determined by peroxide value; hence the level of peroxide value indicates the level of rancidity.

Rescue of pearl millet flour from rancidification:

Anti-nutrients or Anti-oxidants:

Anti-nutrients are naturally occurring compounds [polyphenols, tocopherols (vitamin E), flavonoids and ascorbic acid (vitamin C)] in a variety of cereals and legumes that can also be produced artificially [propyl 3,4,5-trihydroxybenzoate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT)], which interfere with absorption of minerals and vitamins (Jiang et al., 2016). Polyphenols, an anti-nutrient highly concentrated in pearl millet grain and act as a defender of seed from pest, bugs and others. It protects the cereals flour and fat containing food against rancidity by preventing the oxidation fat and also prevents the free radicals formation.

Pearl millet generally has no anti-nutrients factor compared to other crops like sorghum which is condensed with tannin. Pearl millet germ mainly contains nicotinic acid and phytic acid while the peripheral area of seed contains polyphenols (Simwemba et al. 1984). Gray colour of pearl millet seed is due to polyphenols which minimize the use of starch and protein (Pawar and Parlikar 1990), either by binding directly with protein or inhibition of digestive enzymes like amylase and trypsin (Singh 1984).

Storage techniques:

Currently, many studies have explained that the shelf life of pearl millet flour can be enhanced by proper storage, combination of fermentation and malting. Akinola et al. (2017) studied the effect of different pre-processing techniques like fermentation, debranning, malting and blanching on the physiochemical properties of pearl millet flour in order to improve pearl millet flour utility in agricultural or food industries.

Challenges:

3. Anti-nutrients like Polyphenols will reduce the rancidity of pearl millet flour but increase in anti-nutrient will decrease the nutritional profile of pearl millet and also cause health effects.
4. Using breeding strategies for the development of resistant/less susceptible varieties/hybrids of pearl millet in order to overcome the rancidity.

Future prospective

Research need to be focused on the variability in the rancidity profile existing among lines in pearl millet germplasm collections, identify lines having low susceptibility to rancidity and explore the pre-processing, processing and post-processing options of using these low rancidity profile lines to obtain shelf-stable pearl millet flour. The ultimate aim is to reduce drudgery of women and further promote the commercialization and usage of this Nutri-cereal.

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PERFORMANCE OF POPULAR VARIETIES OF BANANA AS INTERCROP UNDER COCONUT ECO-SYSTEM

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Abstract

Field experiment was conducted in Coconut Research Station, Tamil Nadu Agricultural University, Veppankulam, Thanjavur to study the performance of popular varieties of banana as intercrop in coconut eco-system. The materials and methods used were monoculture coconut plantation, designed in Randomized Block Design with eight popular varieties of banana *viz*., Red banana, Neipoovan, Rasthali, Poovan, Monthan, Karpooravalli, Nendran and Grand nine. The observation on growth characters were recorded at 5th month after planting and bunch characters were recorded at the time of harvest. Based on the results,It is concluded that monthan variety was found to be best suited for intercropping in coconut both in terms of bunch weight and leaf production.

Introduction

Coconut plantations have valuable land for other purposes, such as for intercropping system implementation. On the other hand, most coconut lands are cultivated in monoculture system or unarranged mix cropping system. This farming practice results low productivity referring to farmer income as well as their welfare. Rationally, monoculture of coconut plantation can't guarantee the prosperous farmers (Ibrahim Erik Malia and Yusuf, 2012). For effectiveness of intercropping it is necessary to consider the kind of intercrops in developing coconut- based farming system tolerant for environmental limitation especially light. For, example, banana. light has influence on the growth and yield of banana. On the other hand, there are many reasons considered that banana is still possible to use as intercrops within coconut based farming system, such as the light transmission to the grown still possible for certain varieties. Banana widely popular and important food usually cultivated in intercropping system around the world (Olivier *et al*., 2006). Intercropping banana in coconut interspaces is a profitable venture recommended in many places in India (Rao *et al*., 2008). The intercropping of banana under coconut have not been systematically studied. Therefore, this evaluation study was initiated with the objectives to find the cultivar suitability of banana under coconut and to study the performance of various cultivars systematically.

Methodology

Field experiment was conducted during 2019 to March 2022 at Coconut Research Station, Veppankulam, Thanjavur to study the performance of popular varieties of banana as intercrop in coconut eco-system. The experiment was comprised of eight treatments (banana varieties) with three replications laid out in RBD. The treatment consists of eight varieties of banana (Red banana, Neipoovan, Rasthali, Poovan, Monthan, Karpooravalli, Nendran and Grand nine). The popular varieties of banana were planted under 42 years old ECT coconut garden with spacing of 25 x 25 feet at square method. The banana suckers were planted at spacing of 2.5 m x 2.5 m spacing in between two rows of coconut palms. The plants were irrigated with drip system. The observation on growth characters *viz*., plant height (m), stem girth (cm), PCA (cm^2), number of leaves/plant, leaf area (m^2) were recorded at 5^{th} month after planting and bunch characters were record at the time of harvest.

Banana varieties intercropped in coconut

Result

Growth characters

The data indicated that significantly the highest plant height (2.50 m) was registered with Mondhan (T5) and the lowest height were with Grand naine (1.50 m) (T7) and Red banana

(1.61m) (T1). With respect to stem girth and PCA (Pseudostem Cross section Area), significantly maximum value of 65.0 cm and 336.4 cm^2 respectively were found with Karpooravalli (T6) and it was on par with Mondhan (T5). Among the eight varieties, the lowest stem girth (50.0 cm) and PCA (199.2 cm^2) were recorded with Grand naine (T8).

Significantly the highest number of leaves/plant (19.0) was registered with Neipoovan (T2) and it was comparable with all other varieties except Red Banana and Grand naine. With respect to leaf area per plant, Mondhan (T5) recorded significantly highest value of 19.1 m^2 and it was comparable with Karpooravalli (T6) with value of 18.2 m^2. The lowest leaf area was found with Red Banana (13.2 m^2) and Grand naine (13.3 m2).

The observed data were statistically analyzed and the results are given in Table 1.

Table 1. Growth characters of Banana varieties at 5 th month after planting under coconut

Varieties	Plant height (m)	Stem girth (cm)	PCA (cm^2)	No. of leaves/plant	Leaf Area (m^2)
T_1 Red banana	1.61	53.2	238.3	13.5	13.2
T_2 Neipoovan	2.00	51.8	213.6	**19.0**	13.7
T_3 Rasthali	1.80	55.5	245.2	18.3	14.3
T_4 Poovan	2.00	56.3	252.4	15.8	15.0
T_5 Monthan	**2.50**	60.0	30 6.6	18.3	**19.1**
T_6 Karpooravalli	2.39	**65.0**	**336.4**	18.3	18.2
T_7 Nendran	2.10	52.3	217.7	17.3	15.2
T_8 Grand Naine	1.50	50.0	199.2	15.5	13.3
SED	0.15	3.71	17.0	1.19	1.06
CD (5%)	0.33	7.86	36.5	2.55	2.27

Bunch characters

The matured banana bunches were harvested. At the time of harvest, yield attributing characters *viz.*, bunch weight, number of hands/bunch and total number of fruits/bunch are presented in Table 2.

Table 2. Bunch characters and yield of banana varieties under coconut

Varieties	No. of hands			No. of fruits			Bunch weight (Kg)		
	MC	R1	R2	MC	R1	R2	MC	R1	R2
T_1 Red banana	5.17	4.70	--	64.58	58.77	--	14.74	13.41	--
T_2Neypoovan	10.17	9.25	8.64	125.93	114.60	107.04	6.10	5.55	5.19
T_3Rasthali	7.22	6.57	--	87.94	80.03	--	8.65	7.87	--
T_4 Poovan	**10.92**	**9.94**	**9.28**	159.5	145.15	135.58	17.62	16.03	14.98
T_5 Monthan	6.25	5.69	5.31	65.58	59.68	55.74	**18.42**	**16.77**	**15.66**
T_6Karpooravalli	10.58	9.63	8.99	**160.42**	**145.98**	**136.36**	14.36	13.07	12.21
T_7Nendran	5.28	4.80	4.49	45.11	41.05	38.34	10.22	9.31	8.69
T_8 Grand Naine	10.08	9.17	8.57	150.28	136.75	127.74	25.29	23.01	21.50
S.Ed	0.084	0.176	0.158	2.751	2.658	1.111	0.185	0.352	0.214
CD 5%	0.181	0.387	0.339	5.900	5.702	2.382	0.397	0.756	0.456

MC- Main crop; R1- first ratoon and R2- second ratoon.

Performance of banana varieties with respect to yield characters, the highest number of hands was associated with Poovan and it was followed by Karpooravalli. However, Karpooravalli recorded the highest number of fruits and it was closely followed by Poovan. But variety Monthan recorded the highest bunch weight and it was followed by Poovan. The same trends of results were observed in main crop as well as in the first and second ratoon.

Conclusion

Monthan variety was found to be best suited for intercropping in coconut both in terms of bunch weight and leaf production. This was followed by Karpooravalli and Poovan.

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AUTONOMOUS AGRICULTURAL MACHINERY: AI-DRIVEN INNOVATIONS FOR FARM AUTOMATION

Article ID: AG-VO4-I10-33

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Abstract

Artificial intelligence (AI)-powered autonomous agricultural machinery is revolutionizing the agricultural sector by enabling autonomous decision-making and precise control of tasks. Real-time data analytics, such as weather forecasts and crop monitoring, optimize resource allocation, leading to increased efficiency, productivity, and profitability for farmers. Automation of labor-intensive activities like planting, harvesting, and weed management addresses labor shortages and enhances operational efficiency and scalability. AI-driven machinery promotes sustainability by minimizing resource wastage and environmental impact through targeted input application and precision farming techniques. However, challenges such as data privacy concerns, regulatory hurdles, and the digital divide must be addressed to ensure equitable access and responsible deployment of these technologies. Despite these challenges, the transformative potential of AI-driven autonomous machinery in revolutionizing farming practices and fostering a more resilient and sustainable food system is undeniable.Continuous research, collaboration, and investment are essential to harness the full potential of these innovations for the benefit of farmers, consumers, and the planet. Autonomous tractors contribute to sustainable farming practices and global efforts towards food security and environmental conservation. Crop monitoring drones, equipped with high-resolution cameras, multispectral sensors, and advanced imaging techniques, provide detailed insights into crop health, resource allocation, and overall productivity.

Keywords: Autonomous agriculture, Artificial intelligence, Precision farming, revolutionizing farming, Drone, Modern agriculture, Pest infestation

Introduction

Migration, heavy labour, and the expansion of the service sector have all contributed to the sharp decline in agricultural employment, which has a detrimental effect on national food security and raised the agricultural trade balance deficit. Women make up the bulk of the workforce in agriculture. Farming methods have been completely transformed by technological innovations including remotely operated machinery and automatic navigation for tractors and combine harvesters. With advantages including timely operations, better production, and decreased labour, autonomous agricultural machinery is essential for a variety of farming tasks like tillage, planting, weeding, spraying, and harvesting. When compared to manually operated equipment, these machines improve precision and efficiency in agriculture by carrying out all necessary tasks with reduced energy consumption.

Applications of automated agricultural vehicles

There are several advantages to automated agricultural vehicles, including improved safety, accuracy, and productivity. Farmers might soon be expected to use dependable and reasonably priced autonomous cars for a variety of agricultural activities as a result of the industry's rapid innovations, which have produced a wide range of autonomous machinery. Tractors, automated rice Trans planters, semi-robotic agricultural robots, autonomous guiding systems, and robot cars are examples of recent innovations.

Figer1. Different type of automated agricultural machinery

Definition and types of autonomous agricultural machinery

Autonomous agricultural machinery is a piece of self-driving farm equipment that performs its duties without an operator sitting in the cab (Herrmann & Stadler, 2018) Examples - Autonomous Tractors, Harvesting Robots, Crop Monitoring Drones, Weed Control Robots and others.

Autonomous tractor

These are farm vehicles that are autonomously driven by an intelligent system that directs them for optimal operation. Large agricultural landscapes are where autonomous vehicles are employed because there are no buildings to collide with. Additionally, they aid farmers in increasing crop yields. These autonomous vehicles operate in the field using intelligence, and they are equipped with several sensors that collect precise farm data for in-the-moment analysis.

Figer 2. Autonomous tractor

GPS Guidance System

Often referred to as tractor auto-steering or tractor GPS navigation, tractor GPS guidance is a method that precisely positions and guides tractors and other agricultural equipment using GPS. Two primary techniques underpin autonomous guidance: positioning and control. It is possible to position tractors locally or worldwide. Tractor guiding uses global positioning technologies such as Global Navigation Satellite technologies (GNSS) and laser triangulation.

Sensor technologies

It is necessary for an autonomous tractor to have sensors—such as cameras, lasers, LiDars, proximity sensors, or ultrasound—that can sense its surroundings. These sensors assist the car in making decisions, identifying barriers, and identifying farming. Sensors are essential to industrial automation because they help make manufacturing automated and intelligent.

Harvesting robots

Fruits and vegetables are among the crops that harvesting robots are intended to harvest. When the crops are ready to be picked, they employ sensors and cameras to determine this. Robotic arms or other instruments are then used to delicately harvest the crops without causing any damage to the produce. Every seed that is planted must, given the right circumstances, develop into a fully developed plant. Harvests rise as a result of farming practices designed for optimal productivity.

Challenges of harvesting robot

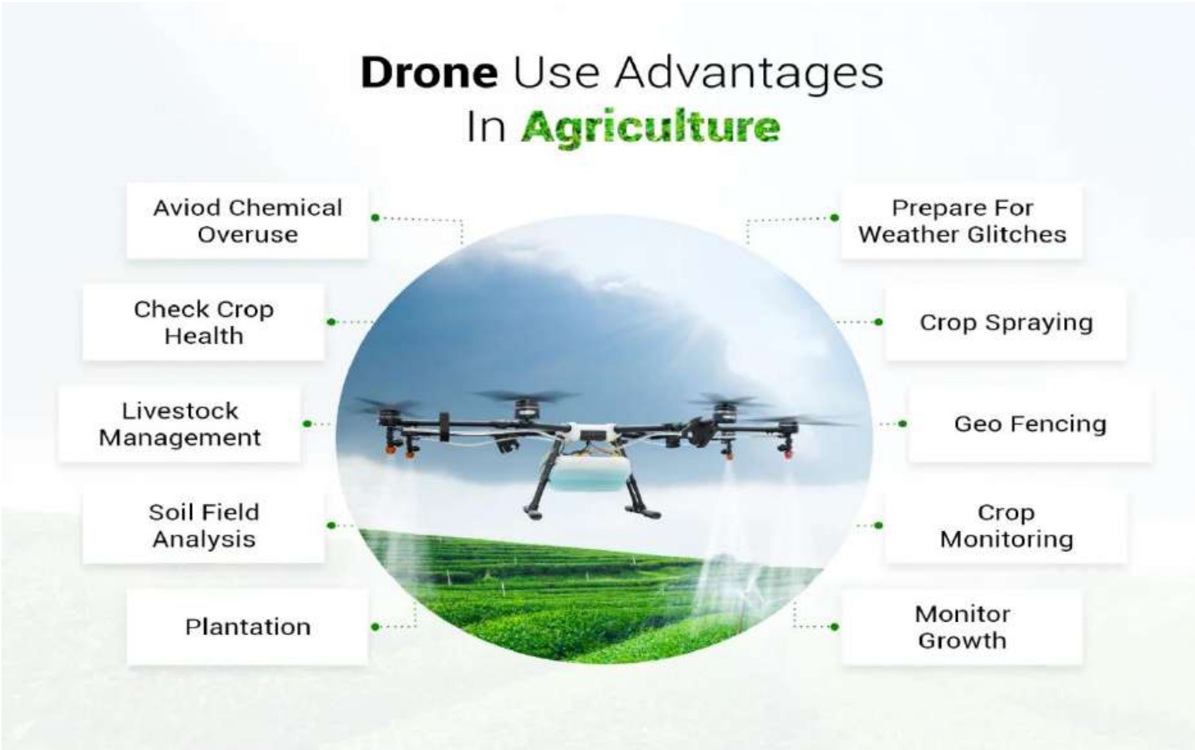
1. Integration with Existing Systems: Integrating new robots into your existing production setup is crucial but can be tricky.
2. Skilled Workforce Shortage.
3. Cost and Investments.
4. Safety and Compliance.
5. Technical Challenges and Maintenance.
6. Inflexibility: This lack of coordination is a further challenge in industrial robotics.

Crop monitoring drones

Drones equipped with special imaging equipment called Normalized Difference Vegetation Index (NDVI) use detailed colour information to indicate plant health. This allows farmers to monitor crops as they grow so any problems can be dealt with fast enough to save the plants.

Figer 3. Crop monitoring drone

Use and advantages of drones in agriculture



Machine Types	Key Metrics	Data Points	Impact on Farming
Autonomous Tractors	Operational Efficiency	- Fuel savings: Up to 15% - Labour reduction: Up to 50% - Precision: 1-2 cm accuracy	Reduces fuel and labour costs, enhances precision in field operations
Autonomous Harvesters	Harvesting Efficiency	- Yield increase: Up to 10% - Sorting speed: 5-10 acres/hour - Waste reduction: Up to 20%	Increases yield and reduces waste through precise and efficient harvesting

Crop monitoring Drones	Crop Monitoring and Analysis	- Coverage area: 50-100 hectares per flight - Resolution: 1-2 cm per pixel - Data processing time: 1-2 hours	Enhances crop health monitoring and precision agriculture through detailed aerial data.
Robotic Weeders	Weeding Efficiency	- Weeding accuracy: 95% - Herbicide use reduction: Up to 70% - Operational speed: 0.5-1 ha/hour	Minimizes herbicide use and reduces manual labour with high accuracy.

Table 1. Different machine types and their impact on farming

Artificial intelligence in agriculture

Precision Farming: AI helps in analysing data from various sources such as satellites, drones, and sensors to optimize field management.

Predictive Analytics: AI models can predict crop yields, disease outbreaks, and weather patterns, helping farmers make better decisions.

Automated Machinery: AI-powered machinery, such as autonomous tractors and harvesters, can perform tasks with high precision.

Disease and Pest Detection: AI systems, often using image recognition, can identify plant diseases and pests early. Drones or cameras capture images of crops, and AI algorithms analyse them to detect issues before they spread, allowing for targeted treatment.

Supply Chain Optimization: AI can improve the efficiency of agricultural supply chains by predicting demand, managing inventory, and optimizing transportation routes. This helps in reducing waste and ensuring that produce reaches markets in the best condition.

Robotics: Robots equipped with AI can perform tasks such as planting, weeding, and harvesting. These robots can operate in diverse conditions and handle tasks that are labour-intensive or difficult for humans.

Climate Adaptation: AI can help farmers adapt to changing climate conditions by analysing data on weather patterns and crop responses. This enables the development of new crop varieties and farming practices suited to evolving environmental conditions.

Decision Support Systems: AI-driven platforms provide farmers with actionable insights and recommendations based on data analysis. These systems can guide decisions on crop rotation, irrigation schedules, and more.

Soil Monitoring: AI can analyse data from soil sensors to monitor moisture levels, temperature, and nutrient content. This information helps in managing soil health and improving crop productivity.

Water Management: AI can optimize irrigation systems by analysing weather forecasts, soil moisture levels, and crop needs, ensuring efficient water usage and reducing waste.

Challenges of autonomous agricultural machinery

1. Infrastructure Deficits
2. High Costs
3. Skilled Workforce
4. Regulatory Hurdles
5. Farm Size and Fragmentation
6. Awareness and Adoption
7. Data Privacy and Security
8. Environmental and Social Impact

Conclusion

AI-driven autonomous agricultural machinery is poised to revolutionize farm automation, offering enhanced efficiency, productivity, and sustainability. These innovations hold immense promise for addressing labour shortages, optimizing resource management, and promoting eco-friendly farming practices. However, overcoming challenges such as data privacy concerns and accessibility issues will be crucial to realizing the full potential of these advancements and creating a more resilient and sustainable food system.

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WATER CHESTNUT: A NUTRITIOUS AND THERAPEUTIC AQUATIC FRUIT

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Abstract

Water chestnut (Trapa natans), also known as "Singhara" or "Paniphal," is an aquatic plant cultivated in shallow water bodies, particularly in India and China. This fruit is rich in carbohydrates, fiber, potassium, iron, calcium, and antioxidants, making it highly nutritious and beneficial for health. It is commonly consumed raw, boiled, or processed into gluten-free flour, which is ideal for diabetic and celiac patients due to its low glycemic index. Despite its nutritional benefits, water chestnut processing faces challenges due to the fruit's hard outer shell, making peeling labor-intensive and inefficient using traditional methods.Technological advancements in peeling and drying techniques, inspired by root crop machines like those for potatoes and yams, offer potential solutions. Mechanized peeling can enhance efficiency, while optimized drying methods, such as hot water pretreatment and microwave drying, can improve product quality and extend shelf life. Additionally, water chestnut flour, when properly packaged, remains a valuable gluten-free alternative for therapeutic and dietary applications. Addressing these challenges through engineering innovations could improve the industrial use of water chestnut, benefiting both food production and the medicinal sector, while promoting its wider adoption as a nutritious and versatile crop.

Key words: Water chestnut, Nutritional benefits, Starchy food alternative, Gluten-free flour, Drying methods and Industrial applications

Introduction:

Water chestnut, also known as "Singhara" or "Paniphal," is an aquatic plant grown in shallow water bodies like lakes, ponds, and marshes, especially in Asian countries like India and

China. Despite its name, the water chestnut is not related to the chestnut but is a unique aquatic angiosperm rich in nutrients and therapeutic properties.

Etymology and Biology

Water chestnut (Trapa natans) has been cultivated for centuries, especially in continental climates. The plant thrives in warm seasons and grows fruits that are triangular with a hard seed coat. The fruit matures during the summer and sinks to the bottom of water bodies in autumn, anchoring in silty sediment. It is most popular in India and China, where it is consumed in various forms—both raw and cooked.

Nutritional Benefits

Water chestnuts are highly nutritious, being low in calories and fat. They are an excellent source of potassium, fiber, vitamins B and E, and antioxidants. Fresh varieties contain more nutrients compared to canned ones, making them a wholesome, natural food. They are rich in starch, with about 80% content, and also provide essential minerals like iron, calcium, and phosphorus.

Physicochemical Properties

Water chestnuts have a high water content of around 81% (fresh) and are packed with carbohydrates. They are also rich in fiber, making them ideal for digestive health. The edible portion is mildly sweet with a crisp texture, commonly used in salads, stir-fries, and even desserts.

Therapeutic and Medicinal Uses

Water chestnuts have been used traditionally in folk medicine as a cooling tonic. Their antioxidant properties make them valuable for promoting good health and preventing diseases. Additionally, studies have shown that water chestnut extracts exhibit antibacterial activity, making them potentially useful in health and nutrition.

In conclusion, water chestnuts are not only a delicious and crunchy snack but also a powerhouse of nutrition with significant health benefits. Whether consumed fresh or processed, they provide a natural boost to overall well-being.

Overview of Existing Peeling Machines for Root Crops

1. **Potato Peeling Machine (Mohammed, 2008)**:

Features: Six stainless steel peeling blades, peels 1 kg of potato in 2 minutes.

Efficiency: High, with features like a safety switch, transparent lid, and cord retraction.

Scientific Insight: The use of stainless steel blades ensures corrosion resistance and durability, crucial for consistent peeling performance.

2. **Yam Peeling Machine (Adetoro, 2012)**:

Design: Eccentrically mounted drum rotates at 20-50 rpm with abrasive spins for peeling.

Efficiency: 95.97%, with 3.9% peel loss and a capacity of 3.0 kg/h.

Scientific Insight: The abrasive drum surface enhances mechanical peeling efficiency through friction, though higher speeds risk damaging tubers.

3. **Cassava Peeling Machine (Alhassan et al., 2018)**:

Performance: Peeling efficiency varies from 12.7% to 74% based on drum fill percentage (10%, 35%, 50%).

Scientific Insight: Higher drum fill reduces peeling efficiency due to less contact between the cassava tuber and abrasive surfaces. Increased flesh loss at higher fills results from more aggressive mechanical action.

4. **Potato Peeling Machine (Borkar et al., 2018)**:

Features: Working capacity of 100 kg/h, maximum efficiency of 98.07% with emery roller No. 80 at 100 rpm.

Scientific Insight: The emery roller effectively removes potato skins while the optimal roller speed prevents excessive peel loss, balancing efficiency and product integrity.

5. **Potato Peeling cum Washing Machine (Tyagi et al., 2018)**:

Capacity: 400 kg/h, with peeling efficiency of 97% and low water consumption (6 kg/l).

Scientific Insight: Combining peeling and washing in a single process minimizes water usage while achieving high efficiency, important for large-scale operations.

6. **Multi-Tuber Peeling Machine (Adeshina & Olusola, 2020)**:

Features: Peeling efficiency increases with shaft speed, operating at 350-750 rpm.

Scientific Insight: Higher rotational speeds facilitate surface scratching, a gentler method for peeling, ensuring minimal tuber damage while maximizing peel removal.

The water chestnut (Trapa natans), also known as Singhara, is an aquatic angiosperm that has been cultivated for centuries, particularly in freshwater ecosystems like ponds, lakes, and marshes in tropical and subtropical regions. It plays a significant role as an underutilized agricultural fruit crop in India and other countries. This fruit is renowned for its high starch content and is considered a substitute for starchy foods like potatoes, corn, and wheat. Water chestnuts are consumed raw, boiled, or processed into flour, which is gluten-free and widely used in religious rituals and dietary practices.

Key Characteristics and Uses

1. **Cultivation and Geography**:

Grown in states like Punjab, Bihar, Uttar Pradesh, and regions with freshwater bodies, including the Wular Lake in Jammu and Kashmir.

Two main varieties exist: thorny and thornless.

It has leathery, floating leaves with submerged stems and small, white flowers that yield dark brown fruits.

2. **Nutritional Value**:

Rich in carbohydrates, proteins, fiber, calcium, iron, potassium, and vitamins, making it highly nutritious.

Low in sodium and fat, it contains beneficial phytochemicals and antioxidants that contribute to its medicinal properties.

3. **Health and Medicinal Benefits**:

Water chestnuts possess antidiabetic, antioxidant, and anti-inflammatory properties. They are also known to regulate hypothyroidism and are used in Ayurvedic and Unani medicine.

Singhara flour is commonly used in foods consumed during fasting and is considered ideal for diabetic and celiac patients due to its low glycemic index and gluten-free nature.

4. **Challenges in Processing**:

The hard outer shell of water chestnuts makes peeling labor-intensive and time-consuming. Traditional methods involve roasting, sun-drying, or boiling the fruits.

Processing losses, low kernel recovery, and reduced flour yield present significant challenges.

Innovative methods are needed to improve peeling efficiency, such as the development of machines that can automate this process. Additionally, hot water pretreatment has been proposed to enhance kernel recovery and improve flour quality.

5. **Proposed Solutions**:

Evaluating engineering properties to enhance processing.

Standardizing hot water treatment to gelatinize the starch, making the kernel easier to decorticate.

Developing a mechanized decorming technique to efficiently peel water chestnuts while minimizing damage.

Studying the drying characteristics and optimizing storage conditions to prolong shelf life and retain quality.

In summary, water chestnut is a highly nutritious, versatile fruit crop with considerable potential in both food and medicinal applications. However, its widespread industrial use is hampered by challenges in processing, storage, and handling, which require systematic study and technological intervention to improve efficiency and product quality.

Drying Techniques for Water Chestnut and Similar Crops

1. **Sweet Potato Drying (Diamante & Munro, 1991)**:

   Factors: Drying temperature, humidity, air velocity, and thickness affect drying efficiency.

   Scientific Insight: The modified Page equation best describes thin-layer drying, useful in optimizing drying parameters for energy efficiency and product quality.

2. **Potato Slices Drying (Magee & Wilkinson, 1992)**:

   Observation: Drying is limited by liquid diffusion rather than capillary flow, with no constant-rate drying period.

   Scientific Insight: Understanding diffusion-limited drying is essential for improving drying techniques in tubers, where moisture content affects texture and rehydration quality.

3. **Water Chestnut Drying (Attanasio et al., 2004)**:

   Study: Compared drying at 40 ºC and 60 ºC, observing morphological changes and increased pore volume at higher temperatures.

   Scientific Insight: High-temperature drying opens starch granules, enhancing rehydration but risking structural damage, critical for tailoring drying processes based on desired end-use.

4. **Microwave Drying of Carrots (Hosain et al., 2012)**:

   Result: Higher microwave power (200-500 W) speeds up drying with significant effects on drying time, diffusivity, and energy consumption.

   Scientific Insight: Microwave drying offers rapid moisture removal, with optimized power settings reducing energy costs while preserving product quality.

5. **Chestnut Drying for Aflatoxin Prevention (Prencipe et al., 2018)**:

   Key Findings: Drying chestnuts at 45-50 ºC controls fungal growth and aflatoxin production, with higher phenolic content but reduced antioxidant activity.

   Scientific Insight: Safe storage of chestnuts requires careful drying to inhibit aflatoxin, and phenolic content can be enhanced, which is important for extending shelf life.

Utilization and Storage of Water Chestnut Flour

1. **Low Glycemic Index (GI) Flour (Brand-Miller et al., 2003)**:

Context: Chestnut flour has low GI, making it suitable for diabetes management.

Scientific Insight: The high nutritional value and low GI of chestnut flour support its use in therapeutic foods, particularly in diabetic diets.

2. **Gluten-Free Chestnut Flour (Sacchetti et al., 2004)**:

Application: Ideal for gluten-free products due to its high starch and protein content.

Scientific Insight: Chestnut flour's composition supports functional food development, offering an alternative for people with gluten intolerance while providing essential nutrients.

3. **Storage Stability (Kleinhenz et al., 2000)**:

Study: LDPE packaging extends the shelf life of water chestnut, minimizing weight loss during storage.

Scientific Insight: Proper packaging materials and storage temperatures reduce respiration rates and water loss, essential for maintaining the quality of chestnuts during long-term storage.

Conclusion

Technological advancements in peeling and drying machines for root crops like potatoes, yams, and cassava show improved efficiencies through the optimization of mechanical design and operational parameters. Simultaneously, innovative drying methods ensure the retention of product quality and shelf life, especially for crops like water chestnut. These developments are significant for industries seeking to enhance production capabilities while maintaining food safety and nutritional value.

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POST-HARVEST HANDLING OF CUSTARD APPLE (ANNONA SQUAMOSA)

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Abstract

Custard apple, a climacteric fruit with a delicate texture and rich nutritional profile, requires meticulous post-harvest handling to preserve its quality and extend shelf life. This paper discusses the development and functionality of a custard apple pulp extracting device, which efficiently separates the pulp from seeds and skin, optimizing yield while maintaining pulp integrity. Key components of the device, including the feeding system, crushing mechanism, separation chamber, and collection system, are designed to enhance productivity and pulp quality. Proper storage practices, such as freezing and pasteurization, are also explored to preserve the nutritional value and extend the usability of custard apple pulp. Additionally, the paper highlights various value-added products derived from custard apple pulp, ranging from beverages and desserts to jams and even cosmetic applications. These innovations not only reduce post-harvest losses but also offer diverse market opportunities, promoting the wider use of custard apple pulp in the food processing and wellness industries.

Key word: Custard apple, pulp extraction, post-harvest handling, shelf life, food processing, value-added products, pulp storage, edible coatings, freezing, preservation techniques.

Introduction

Custard apple, known for its unique flavor and nutritional benefits, is a climacteric fruit that requires careful post-harvest handling to maintain its quality and extend its shelf life. Due to its soft texture and high perishability, proper post-harvest practices are essential to minimize losses and deliver fresh produce to the market.

A pulp extracting device for custard apple is designed to efficiently separate the pulp from the seeds and skin, maximizing yield and maintaining the quality of the pulp. Given the custard apple's delicate structure and high sugar content, a well-designed device is essential for optimal extraction. Effective storage of custard apple pulp involves maintaining appropriate temperature and humidity, using suitable containers, and employing preservation techniques such as freezing and pasteurization. By following these practices, the quality and nutritional value of custard apple pulp can be preserved for extended periods, making it a valuable ingredient for culinary uses.

A custard apple pulp extracting device streamlines the process of obtaining high-quality pulp from this delicate fruit. By integrating effective crushing, separation, and collection mechanisms, the device enhances productivity and ensures a higher quality of extracted pulp suitable for various culinary applications. Value-added products from custard apple pulp not only enhance the fruit's market value but also cater to diverse consumer preferences. By utilizing custard apple pulp creatively, producers can tap into various segments of the food and wellness markets, promoting healthier eating and lifestyle choices.

1. Harvesting Stage:

Custard apples should be harvested at the right stage of maturity to ensure optimal ripening and quality. The following indicators can help determine the appropriate time for harvesting:

The fruit's color turns from green to a lighter green or yellowish hue.

Segments on the fruit’s skin start to separate slightly.

The fruit softens at the base when gently pressed.

Early or late harvesting can affect the fruit’s flavor, texture, and shelf life. Harvesting should be done manually to avoid damage, preferably in the early morning or late afternoon when temperatures are cooler.

2. Pre-Cooling:

After harvest, custard apples should be pre-cooled to remove field heat. This helps slow down the respiration rate and delays ripening, preventing spoilage. Forced air cooling or hydrocooling is commonly used, with temperatures maintained between 10°C to 15°C.

3. Grading and Sorting:

Post-harvest grading is essential to categorize fruits based on size, color, and maturity. Sorting also helps remove any damaged, diseased, or under-ripe fruits. Fruits are typically graded into categories such as extra-large, large, medium, and small, depending on market requirements.

4. Washing and Disinfection:

To reduce the microbial load, the fruits should be washed using clean water or a mild disinfectant solution such as chlorine. This step helps to minimize fungal infections and spoilage during storage.

5. Packaging:

Proper packaging is crucial to protect the delicate custard apple fruits during transportation. The following packaging techniques can be applied:

Padding: Soft padding materials like paper or foam should be used to cushion the fruits.

Perforated Plastic Bags: Using breathable plastic bags or clamshell packaging reduces moisture loss and maintains freshness.

Ventilated Crates or Cartons: Fruits should be packed in ventilated containers to allow airflow, preventing the buildup of ethylene, a natural ripening agent.

6. Storage:

Custard apples should be stored in a cool, humid environment to extend shelf life. Optimal storage conditions are:

Temperature: 8°C to 12°C

Relative Humidity: 85% to 90%

Storing custard apples at temperatures below 8°C can cause chilling injury, resulting in browning and poor ripening. Conversely, higher temperatures accelerate ripening and spoilage.

7. Transportation:

Properly refrigerated trucks or cold storage units should be used to transport custard apples to markets. The transportation environment should maintain a consistent cool temperature to prevent premature ripening and physical damage during transit.

8. Post-Harvest Treatments:

To enhance the shelf life and quality of custard apples, certain post-harvest treatments can be applied:

Edible Coatings: Applying natural edible coatings like aloe vera gel or wax can reduce water loss, delay ripening, and improve the fruit's appearance.

Modified Atmosphere Packaging (MAP): MAP techniques, which adjust oxygen and carbon dioxide levels inside the packaging, can slow down the ripening process and extend shelf life.

9. Ripening:

Since custard apples are harvested in an unripe state, controlled ripening is necessary before they are sold to consumers. Ethylene gas can be used to trigger uniform ripening in a controlled environment. It is essential to monitor the process to avoid over-ripening, which can lead to spoilage.

10. Shelf Life:

Under optimal post-harvest conditions, custard apples can be stored for 7 to 10 days. Proper post-harvest handling practices can reduce losses by up to 25%, ensuring higher returns for growers and better quality for consumers.

Pulp Extracting Device for Custard Apple Pulp

Key Components of the Device:

1. **Feeding System:**

    Hopper: A large opening where the whole custard apples are fed into the machine.

    Conveyor Belt (optional): Moves the fruits toward the extraction mechanism, ensuring a continuous flow.

2. **Crushing Mechanism:**

    Roller or Blade System: A set of rollers or blades crushes the custard apples to break down the fruit's structure, allowing easier access to the pulp.

    Adjustable Pressure: The device may feature adjustable pressure settings to accommodate different fruit sizes and ripeness levels, ensuring effective crushing without excessive damage.

3. **Separation Chamber:**

    Mesh Screens or Filters: After crushing, the mixture of pulp, seeds, and skin is passed through mesh screens or filters that allow only the pulp to pass through while retaining seeds and larger fibrous materials.

    Variable Mesh Sizes: Different mesh sizes can be used to adjust the fineness of the extracted pulp based on the desired consistency.

4. **Collection System:**

    Pulp Collection Container: A container collects the extracted pulp, ensuring easy transfer for further processing or packaging.

Waste Discharge Outlet: An outlet for the discarded seeds and skin, allowing for continuous operation without manual intervention.

5. **Power Source:**

Electric or Manual Drive: The device can be powered electrically for high efficiency or designed as a manual-operated machine for smaller operations.

Advantages of Using a Pulp Extracting Device:

Efficiency: Significantly reduces the time and labor involved in manual pulp extraction.

Higher Yield: Maximizes the amount of pulp extracted while minimizing waste.

Quality Preservation: Maintains the freshness and quality of the custard apple pulp, essential for food processing.

Scalability: Suitable for both small-scale and industrial production, adaptable to different production capacities.

Applications:

Food Processing Industry: Used in the production of beverages, ice creams, and desserts.

Home Use: Smaller versions of the device can be used in kitchens for making fresh custard apple pulp for immediate consumption.

Pulp Storage of Custard Apple

Proper storage of custard apple pulp is crucial to maintaining its quality, flavor, and nutritional value. The following are key considerations and best practices for storing custard apple pulp effectively.

1. Storage Conditions

Temperature: Custard apple pulp should be stored at low temperatures to slow down the spoilage process. The ideal storage temperature is typically between 0°C and 4°C (32°F to 39°F). This can be achieved through refrigeration.

Humidity: Maintain moderate humidity levels (around 85-90%) to prevent dehydration and maintain pulp quality without promoting mold growth.

2. Storage Containers

Food-Grade Containers: Use airtight, food-grade containers made of glass, plastic, or stainless steel to store the pulp. Avoid using metal containers that may react with the acids in the pulp.

Vacuum Sealing: For longer storage, vacuum-sealing the pulp can help eliminate air and prevent oxidation, extending shelf life significantly.

3. Preservation Methods

Freezing: If long-term storage is needed, custard apple pulp can be frozen. Portion the pulp into smaller containers or freezer bags, leaving some headspace to allow for expansion during freezing. Properly frozen pulp can last up to 6-12 months.

Pasteurization: For commercial purposes, pasteurization of the pulp before storage can help eliminate microorganisms and extend shelf life. The pulp is heated to a specific temperature for a set duration and then cooled rapidly before storage.

4. Labeling and Rotation

Label Containers: Clearly label containers with the date of extraction and storage to monitorfreshness.

First-In, First-Out (FIFO): Implement a FIFO system to ensure older pulp is used first, minimizing waste and ensuring quality.

5. Monitoring Quality

Regular Checks: Periodically check the stored pulp for any signs of spoilage, such as off odors, discoloration, or mold growth. Discard any compromised pulp immediately.

Sensory Evaluation: Conduct sensory evaluations before use, assessing taste, aroma, and texture to ensure the pulp remains of high quality.

6. Utilization

Thawing: When using frozen pulp, thaw it in the refrigerator overnight or use a microwave on low power to prevent cooking the pulp. Avoid thawing at room temperature to reduce the risk of bacterial growth.

Processing: Utilize stored pulp in various culinary applications such as smoothies, desserts, sauces, and beverages, ensuring freshness is preserved until consumption.

Custard apple pulp is a versatile ingredient that can be transformed into various value-added products. Here are some popular products derived from custard apple pulp, highlighting their features, preparation methods, and potential benefits:

1. Custard Apple Juice

Description: A refreshing beverage made by blending custard apple pulp with water, sugar, and lemon juice.

Preparation: Blend the pulp with water to the desired consistency, strain to remove fibers, and sweeten as needed. Serve chilled.

Benefits: Rich in vitamins A and C, custard apple juice is hydrating and nutritious.

2. Custard Apple Ice Cream

Description: A creamy dessert that combines custard apple pulp with milk, cream, and sugar.

Preparation: Mix custard apple pulp with cream, milk, sugar, and a stabilizer (if desired). Churn in an ice cream maker or freeze in a container, stirring occasionally to break ice crystals.

Benefits: Provides a delicious way to enjoy the nutritional benefits of custard apple, appealing to both children and adults.

3. Custard Apple Pudding

Description: A smooth, sweet dessert made from custard apple pulp, milk, sugar, and cornstarch.

Preparation: Cook milk and sugar with cornstarch until thickened, then fold in custard apple pulp. Pour into molds and refrigerate until set.

Benefits: A nutritious and easy-to-make dessert that can be enhanced with spices like cardamom.

4. Custard Apple Smoothies

Description: A blended drink combining custard apple pulp with yogurt or milk and other fruits.

Preparation: Blend custard apple pulp with yogurt, a banana, and ice cubes. Adjust sweetness if necessary.

Benefits: A nutritious breakfast option packed with fiber, vitamins, and minerals.

5. Custard Apple Jam

Description: A sweet spread made from custard apple pulp, sugar, and pectin.

Preparation: Cook custard apple pulp with sugar and pectin until thickened. Pour into sterilized jars and seal.

Benefits: Offers a longer shelf life and a convenient way to enjoy the flavor of custard apple year-round.

6. Custard Apple Syrup

Description: A sweet syrup made from custard apple pulp and sugar, often used as a topping for pancakes or desserts.

Preparation: Cook custard apple pulp with sugar and a splash of water until thickened. Strain to remove solids.

Benefits: Adds flavor to various dishes and can be used as a natural sweetener.

7. Custard Apple Cake

Description: A moist cake made by incorporating custard apple pulp into the batter.

Preparation: Mix custard apple pulp with flour, sugar, eggs, and baking powder. Bake until golden brown.

Benefits: A delicious way to include the nutritional benefits of custard apple in baked goods.

8. Custard Apple Chutney

Description: A tangy-sweet condiment made with custard apple pulp, spices, and vinegar.

Preparation: Cook custard apple pulp with vinegar, sugar, and spices until thickened. Jar and seal.

Benefits: Adds a unique flavor to savory dishes and is rich in vitamins.

9. Custard Apple Bars

Description: Healthy snack bars made with custard apple pulp, oats, nuts, and honey.

Preparation: Mix custard apple pulp with oats, chopped nuts, and honey. Press into a pan, refrigerate, and cut into bars.

Benefits: A nutritious snack rich in fiber and healthy fats.

10. Custard Apple Face Mask

Description: A natural cosmetic product using custard apple pulp for skin benefits.

Preparation: Mix custard apple pulp with yogurt and honey to form a paste. Apply to the face and leave for 15-20 minutes before rinsing.

Benefits: Nourishes the skin, providing hydration and promoting a glowing complexion.

Conclusion

Efficient post-harvest handling of custard apple is critical to maintaining fruit quality, extending shelf life, and minimizing post-harvest losses. By adopting the right harvesting, pre-cooling, packaging, and storage techniques, farmers and distributors can ensure the delivery of high-quality custard apples to the market, enhancing both profitability and consumer satisfaction.

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HEMODIALYSIS IN DOGS: A LIFE-SAVING TREATMENT FOR KIDNEY FAILURE

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Abstract

Dogs are highly susceptible to kidney failure which is a common disease that is very difficult to diagnose in the early stages. Hemodialysis is utilized as an advanced therapy for dogs suffering from acute or chronic renal failure, as it mimics the function of the damaged kidneys. To diagnose kidney failure at early stages and start hemodialysis treatment, understanding the etiology, clinical signs, and diagnostic methods of canine kidney failure is significant. An overview of intermittent hemodialysis (IHD), the materials used, and the processes involved in performing IHD are described. With continuous innovations in veterinary medicine effective dialysis services are likely to be offered. With such developments on the horizon and growing awareness among veterinarians and pet owners, the future of dialysis in veterinary medicine remains promising, opening up possibilities such as the use of hemodiafiltration to increase the effectiveness of therapy in treating sick animals with renal disease.

Keywords: Dogs, Dialyzer, Intermittent hemodialysis, Kidney failure,

Introduction

Kidney failure in dogs is increasingly a common condition in dogs, where the kidneys fail to remove the waste from blood. The causes of acute and chronic kidney disease include severe dehydration, toxins, infection, heart failure, severe burns, urinary tract infections, and many more. Early detection of kidney failure in dogs is challenging as dogs do not show noticeable symptoms until the disease progresses to more advanced stages. At the advanced stage, where the kidney function is severely compromised dialysis is the life-saving option. Dialysis in dogs is an advanced treatment for severe kidney failure that acts as an artificial replacement of kidney function, giving time to the kidneys for recovery. This has two main types

– Hemodialysis and Peritoneal dialysis which are commonly practiced in veterinary medicine. Prolonged intermittent renal replacement therapy (PIRRT) and Sustained low-efficiency **daily dialysis (SLEDD) are hybrid therapies for critically ill** patients which has not been widely implemented in dogs but it is theoretically possible with advanced veterinary care and specialized equipment. This article focuses on hemodialysis in dogs. With the rapid advancement of veterinary medicine and the availability of canine dialysis, pet owners are feeling more optimistic than ever. The future of veterinary dialysis aims to make the process more efficient, cost-effective, and available in more veterinary hospitals.

Kidney Failure in Dogs:

Kidney failure in dogs could be of acute or chronic failure. Acute kidney failure (AKF) happens suddenly as a result of immediate injury or damage to dogs and progresses rapidly within days or hours. The cause of AKF can be classified as

i. Pre-renal causes: When there is reduced blood flow to the kidneys, it causes them to function inadequately. The conditions include severe dehydration, low blood pressure, heart failure, and blood loss or hemorrhage.
ii. Intrarenal (Intrinsic) Causes: Here, there is direct damage to the kidneys. The conditions like ingestion of toxins (Ethylene Glycol, pesticides, NSAIDS, antibiotics like gentamicin, and doxycycline which are nephrotoxic), infections that attack kidney tissues (leptospirosis, tick fever), acute glomerulonephritis, autoimmune diseases, trauma to kidneys due to accident.
iii. Postrenal Causes: Occurs when there is an obstruction of urinary flow preventing urine excretion from the body. Here the condition includes urethral obstruction, bladder rupture, and prostate diseases.

Chronic kidney failure is a result of long-term damage to the kidneys which develops over months or years. Some common causes include aging(as the dog ages, the kidney naturally wears) Congenital or genetic conditions, long-term medication(NSAIDs, antibiotics), and Chronic infections(urinary tract infection, diabetes).

COMMON SYMPTOMS AND DIAGNOSIS: Early recognition of symptoms is critical for veterinary intervention. The common signs include polyuria, polydipsia, anorexia, weight loss, vomiting, weakness, uremic breath, pale gums, anemia, and seizure in advanced conditions.

Palpation of the kidneys is an essential diagnostic technique for kidney failure in dogs; in acute kidney failure (AKF), the kidneys may feel painful and swollen, but in chronic kidney failure (CKF), they frequently feel normal. exist as tiny, nodule-like entities.

Hemato-biochemical findings include Azotemia (elevation of BUN and creatinine), Hypoproteinemia, Hypoalbuminemia, Non-regenerative anemia, Hyperphosphatemia, Hypocalcemia, and metabolic acidosis. Radiographic examination to evaluate the shape and size of kidneys. Ultrasonographic examination to locate renal parenchymal disorders

Indications For Dialytic Intervention:

Dialysis is preferred in dogs when medications and all other means are ineffective in managing the dog’s condition. Certain indications include

- Serum creatinine exceeding 5 mg/dL in hydrated animals.
- Persistent (>6 h) anuria or oliguria (<0.3ml/kg/h) unresponsive to appropriate fluid therapy and medical management.
- Severe and life-threatening overhydration, unresponsive to diuretic therapy, and promoting target organ damage.
- Presence of electrolyte disturbances which cannot be controlled with medical or surgical management.

Overview of Hemodialysis

Hemodialysis in dogs is of two types - Intermittent hemodialysis (IHD) where the solute is Dogs can receive one of two types of hemodialysis: intermittent hemodialysis (IHD), in which the solute is eliminated through the mechanism of diffusion over the course of three to six hours, and continuous renal replacement therapy (CRRT), in which the solute is eliminated over the course of 24 hours through the mechanisms of diffusion, convection, or both. Among these IHD is commonly practised in dogs. Before dialysis is performed, the following tests must be conducted: Blood gas analysis, CBC, liver function tests, kidney function tests, urine analysis, radiography of the thoracic and abdominal regions, blood pressure monitoring, ECG, and echocardiography. When a patient is anemic, PCV is less than 25, and body weight is less than 5 kg, dialysis is not preferred. In routine dialysis for dogs, anesthesia is generally not preferred. However, mild sedation might be used in cases where the dog is anxious or requires a catheter insertion.

MATERIALS REQUIRED FOR IHD

Dialysis machine, dialyzer, RO plant, blood tubing set, dialysate, dual lumen catheter, heparin, normal saline, syringes, IV set.

DIALYSIS MACHINE

Separate machines are available in the market for Intermittent hemodialysis and Continuous renal replacement therapy. Some examples of IHD include Fresenius 2008 K, Fresenius 4008 S, Fresenius 4008 B, and Fresenius 5008 S.

DIALYZER

It is commonly referred to as an artificial kidney, which has several hollow fibers (into which blood is passed) that are semi-permeable membranes that allow the passage of waste products and excess substances while retaining blood cells and proteins. The selection of the dialyzer should focus on the following: Surface area of the dialyzer, Priming volume, Characteristics of the filtration membrane (Biomaterial of Dialysis Membrane- Cellulose, Polysulfone, Polyethersulfone), and Biocompatibility. A dialyzer with a smaller surface area (0.3 to 0.5 m2) than recommended may be chosen preferentially in dogs of all sizes for initial hemodialysis treatments when the BUN concentration is greater than 200 mg/dL to reduce the intensity of the treatment and risk of dialysis disequilibrium syndrome(DDS).

DIALYZATE

Dialysate is a crucial fluid that creates the concentration gradient in the dialyzer that allows waste products, toxins, and excess electrolytes to move out of the dog's bloodstream and into the dialysate for removal. It has 3 parts- Part A is an electrolyte solution(containing sodium, potassium, calcium, magnesium, and chloride), Part B is a bicarbonate solution that helps to neutralize acids in the blood, and the third part is water which should be highly purified water from RO plant, which is essential for maintaining the fluid balance in the dog's body.

Body weight	**Surface Area of dialyzer**	**Priming Volume**
<6 kg	0.2 m^2 and 0.4 m^2	<30 mL
6 to 12 kg	0.4 m^2 and 0.8 m^2	<45 mL
12 to 20 kg	1.5 m^2	Upto 80mL
>30kg	>2 m^2	> 100mL

Table 1. Selection of dialyzer based on body weight of animal

DUAL LUMEN CATHETER:

It is used to access the bloodstream for efficient blood removal and return. As the name suggests it has 2 lumens- the arterial lumen(red) draws blood from the dog's body and directs it to the dialyzer via blood tubing, venous lumen(blue) returns the filtered, clean blood back into the dog's circulation after it has passed through the dialyzer. The catheter is fixed in the jugular vein by Seldinger Technique or Modified Seldinger Technique.

BLOOD TUBING SET:

It facilitates the movement of blood between the dog and the dialysis machine with two line-

1. Arterial line(red) connected to the arterial lumen of dual lumen catheter. The arterial line is connected to a pump that regulates the blood flow rate, ensuring smooth and controlled circulation of blood to the dialyzer. This line also has ports to connect NS, and heparin and to give certain medications.
2. Venous line(blue) connected to the venous lumen of dual lumen catheter.

Both the lines have a drip chamber which removes the air and blood clots. Also, a port above the drip chamber is connected to the machine to give the arterial and venous pressure.

DURATION AND FREQUENCY:

Depending on the advanced stage of kidney failure and the individual requirements of the dog, an intermittent hemodialysis session for dogs may be between three to six hours. Likewise, the underlying cause of renal disease and the dog's reaction to treatment will determine how frequently the dog needs dialysis sessions.

Post-Dialysis Care:

After the session, the dog's vital signs, including blood pressure and heart rate, are closely monitored to ensure stability. Repeat blood tests are performed after dialysis to evaluate how effectively the procedure has removed toxins and restored electrolyte balance. The dog's diet must include an unlimited supply of water and decreased dietary protein, sodium, and phosporous levels.

Conclusion

In conclusion, hemodialysis serves as a critical life-saving treatment for dogs suffering from severe kidney failure, offering a chance for recovery when other medical interventions fail. As veterinary medicine continues to advance, more efficient, accessible, and specialized dialysis treatments are becoming available, improving outcomes for dogs with renal disease. With proper care, regular monitoring, and dietary adjustments, hemodialysis can significantly extend and improve the quality of life for affected dogs

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SOIL AMENDMENTS FOR REMEDIATION OF HEAVY METAL CONTAMINATED SOILS

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Introduction

Contaminated soils pose significant environmental and health risks, especially when heavy metals like cadmium (Cd), lead (Pb), arsenic (As), chromium (Cr), and zinc (Zn) are involved. Remediation techniques are essential to mitigate the impact of these pollutants on ecosystems and human health. One effective approach is using soil amendments—materials added to soils to enhance their chemical and physical properties, ultimately improving the soil's ability to immobilize or neutralize contaminants. In recent years, various industrial by-products have gained attention for their ability to remediate contaminated soils due to their chemical composition and cost-effectiveness. The following sections highlight some key industrial wastes and their applications in soil remediation.

1. Pressmud

Pressmud, a by-product of the sugar industry, has shown promising potential in the remediation of contaminated soils. Rich in organic matter and fibers, pressmud enhances heavy metal removal efficiency when combined with other organic materials like rice husk. A study by Ahmad et al. (2016) showed that using pressmud alone could remove up to 95-100% of heavy metals from contaminated water, while rice husk alone removed only 10-20%. The combination of pressmud and rice husk significantly improved metal immobilization. When applied to contaminated soils, pressmud not only helps in heavy metal removal but also improves soil organic content, making it a sustainable amendment for remediation purposes.

2. Steel Slag

Steel slag is an industrial by-product from steel manufacturing, containing high amounts of calcium and silicon, which are crucial for heavy metal immobilization. Several studies have demonstrated the effectiveness of steel slag in stabilizing metals such as Cd, Cu, Pb, and Zn in contaminated soils. For instance, steel slag has been shown to reduce soil acidity, promote plant growth, and decrease the bioavailability of heavy metals. Ning et al. (2016) found that steel slag reduced cadmium concentrations in rice grains grown in contaminated paddy soils. Additionally, the basic properties of steel slag increase soil pH, promoting the precipitation and sorption of metals like Cu, thereby reducing their mobility and uptake by plants.

3. Fly Ash

Fly ash, a by-product of coal combustion, is another valuable amendment for heavy metal remediation. Its high calcium oxide content (CaO) makes it particularly effective in immobilizing metals such as Cu, Pb, and Zn. Fly ash raises soil pH, thereby reducing the solubility of heavy metals and promoting their precipitation as less bioavailable compounds. Studies have shown that fly ash can significantly reduce the concentration of metals in soil solutions and lower metal uptake by plants. For example, Sitarz-Palczak and Kalembkiewicz (2012) observed that fly ash amendments could lower Mn availability in contaminated soils by up to 37%. Fly ash can also be combined with other industrial by-products, such as steel slag, to enhance soil pH and heavy metal stabilization further.

4. Farmyard Manure (FYM)

Farmyard manure (FYM) is a widely available organic amendment that has proven effective in mitigating the impact of heavy metals in soils. FYM adds organic matter to the soil, which enhances the adsorption of metals through complexation processes, reducing their mobility and bioavailability. FYM has been particularly effective in reducing cadmium and lead accumulation in crops like spinach and wheat. Studies have shown that FYM application at rates of 20 tons per hectare can significantly reduce heavy metal uptake in plants, making it a cost-effective solution for soil remediation in agricultural systems.

5. Blast Furnace Slag

Blast furnace slag, a by-product of the iron and steel industry, is another valuable amendment for contaminated soils. It contains calcium, silicon, and aluminum compounds, which help immobilize metals like Cr, Zn, and Pb (Coumar et, al., 2021). The high pH of blast furnace slag enhances metal precipitation and reduces their bioavailability. For example, studies have shown that slag effectively stabilizes hexavalent chromium (Cr(VI)) in alkaline soils by promoting the formation of insoluble chromium compounds. This process not only reduces the mobility of heavy metals but also provides essential nutrients like calcium and silicon to the soil, improving its fertility.

6. Cement Kiln Dust (CKD)

Cement kiln dust (CKD) is a fine powdery material generated as a by-product of cement manufacturing. CKD contains lime (CaO) and other minerals that raise soil pH and facilitate the immobilization of heavy metals. Its application to contaminated soils has been shown to reduce the mobility and bioavailability of metals such as Cd, Pb, and Zn. CKD's alkaline properties promote the formation of insoluble metal hydroxides, which prevent the metals from leaching into groundwater or being taken up by plants. Research indicates that CKD, when applied at appropriate rates, can be a highly effective and economical solution for remediating heavy metal-contaminated soils, especially in industrial areas.

7. Red Mud

Red mud, a by-product of the aluminum industry, is rich in iron oxides, aluminum oxides, and calcium. Its high alkalinity makes it an effective agent for heavy metal immobilization. When red mud is applied to contaminated soils, it raises the pH and promotes the precipitation of metals like Cd, Pb, and Zn as insoluble hydroxides and phosphates. Additionally, red mud's high surface area and porosity enhance its adsorption capacity, further reducing the bioavailability of heavy metals. Studies have shown that red mud can significantly reduce the leaching of metals into groundwater and limit their uptake by plants, making it a valuable tool in soil remediation.

8. Phosphogypsum

Phosphogypsum is a by-product of phosphate fertilizer production, containing calcium sulfate and trace amounts of phosphates. Although it has been primarily used for soil conditioning and improving crop yields, phosphogypsum has also shown potential in immobilizing heavy metals in contaminated soils (Sharkova, 2010). The calcium sulfate in phosphogypsum helps precipitate metals as insoluble sulfates, reducing their mobility and bioavailability. Furthermore, the addition of phosphogypsum can enhance soil structure, improve water retention, and provide essential nutrients to plants, making it a versatile amendment for both remediation and agricultural productivity.

9. Biochar

Biochar, a carbon-rich by-product of biomass pyrolysis, is gaining recognition as a soil amendment with the ability to sequester carbon and immobilize heavy metals. Biochar's high surface area and porosity make it an excellent adsorbent for heavy metals like Cd, Pb, and Zn. In addition, biochar's ability to raise soil pH can further reduce the solubility and mobility of heavy metals (Coumar et al., 2016). Studies have shown that the application of biochar, particularly hardwood and pigeon pea biochar, can significantly reduce the bioavailability of metals in contaminated soils while improving soil health and crop productivity (Mounissamy et al., 2024).

Conclusion

The use of industrial by-products as soil amendments offers a cost-effective and sustainable approach to remediating heavy metal-contaminated soils. Materials like pressmud, steel slag, fly ash, farmyard manure, blast furnace slag, cement kiln dust, red mud, phosphogypsum, and biochar each have unique properties that enhance heavy metal immobilization and improve soil health. By selecting appropriate amendments based on the specific contaminants and soil conditions, these materials can play a vital role in mitigating the environmental and health risks associated with heavy metal contamination. Moreover, utilizing industrial waste in soil remediation not only addresses soil pollution but also promotes the recycling and reuse of industrial by-products, contributing to a circular economy and reducing environmental footprints.

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PROBLEMS, CHALLENGES AND THE FUTURE OF MANAGING PLANT DISEASES: AN ECOLOGICAL PERSPECTIVE

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Abstract

Plant disease management is increasingly challenged by several factors: (i) the rising demand for safe, diverse food to support a growing global population with improving living standards; (ii) reduced agricultural production potential due to competition for fertile land and the degradation of marginal lands; (iii) declining ecological health in agro-ecosystems and the depletion of natural resources; and (iv) heightened risk of disease outbreaks linked to agricultural intensification and monoculture practices. To effectively manage plant diseases in the future, it is essential to enhance food security while protecting ecosystem health and reducing reliance on natural resources. Sustainable disease management strategies should focus on carefully adapting resistance, avoidance, elimination, and remediation techniques, both individually and in combination. This approach should be informed by the specific interactions between hosts and pathogens and guided by principles of evolutionary ecology, aiming to create conditions that promote host growth while hindering pathogen reproduction and evolution.

Introduction

Plant disease has significantly impacted food production and societal development for thousands of years (Palmgren et al. 2015). In the early agricultural period, outbreaks of plant diseases were often perceived as divine punishment, leading to limited management strategies. With generally low crop yields and insufficient food reserves, disease epidemics could quickly result in food shortages, causing catastrophic societal consequences, such as the Irish Famine due to potato late blight in the 1840s and the 1943 Bengal famine linked to rice brown spot.

Although scientific and technological advancements have significantly decreased the frequency and severity of disease outbreaks in recent years, approximately 20-30% of agricultural production is still lost annually to plant diseases (Oerke, 2005). These losses highlight gaps in our understanding of the causes and mechanisms behind epidemics, indicating insufficient methods for effective management, let alone eradication. Additionally, many current plant disease management strategies and agronomic practices in modern agriculture have led to unintended consequences, such as loss of biodiversity and depletion of natural resources (Gonthier *et al*. 2014), environmental degradation (Enserink et al. 2013), and accelerated pathogen evolution (Zhan and McDonald 2013).

Throughout agricultural history, plant disease management has evolved through four main phases: (i) minimal intervention in ancient farming practices; (ii) mechanical and temporal disease control methods such as rogueing, ploughing, and crop rotations; (iii) extensive use of major gene resistances and pesticides before and after the first Green Revolution; and (iv) integrated pest management and ecological approaches that focus on synergistic benefits for the economy, society, and both agricultural and natural ecosystems.

Ecological management of plant diseases is not merely a revival of ancient farming methods. Instead, it seeks to apply evolutionary principles to enhance nature's regulatory functions, fostering environments conducive to healthy crops that yield high and stable outputs. This involves efficiently utilizing both natural and societal resources to promote strong disease resistance and create conditions that hinder pathogen infection, reproduction, transmission, and evolution (Zhan et al. 2015).

Additionally, it is essential to assess the short- and long-term economic and societal effects of each plant disease management strategy. Achieving sustainable plant disease management requires multidisciplinary collaboration across various fields, including natural and biological sciences such as plant pathology, breeding, agronomy, soil science, environmental science, economics, and social science.

The nature of plant disease epidemics and current situation of management

In natural ecosystems, host plants and pathogens are in a constant state of flux, with pathogens evolving new ways to bypass plant defenses while plants develop mechanisms to fend off attacks. These coevolutionary dynamics take place within ecological contexts where environmental variability influences pathogen evolution, and where host evolution is limited by small population sizes and lengthy generation times (Iranzo et al. 2015).

In contrast, modern agricultural systems prioritize high productivity and quality in specific crops and varieties, leading to large-scale, intensive, and specialized cultivation practices. This shift disrupts the natural coevolutionary interactions between host plants and pathogens, resulting in more frequent and severe disease outbreaks and the emergence of new diseases. Unfortunately, many plant disease management strategies implemented over the past 50 to 100 years have failed to account for the relationships among agricultural practices, disease outbreaks, and economic returns within an ecological and evolutionary framework. As a result, efforts to control plant diseases can inadvertently exacerbate the very issues they aim to address.

Plant diseases arise from intricate interactions among biotic and abiotic factors, including hosts, pathogens, and their environments, along with vectors for certain diseases and human activities that alter these interactions—either intentionally or unintentionally—through various agricultural practices, such as cropping systems and the deployment of resistance genes (Burdon et al. 2014), as well as pesticide applications. Over recent decades, many plant disease management practices have fostered ecological conditions that promote pathogen infection, reproduction, transmission, and evolution, thereby heightening the adverse effects of plant diseases on food security and human society.

Ecological environments adverse to host plants but favourable for pathogens

Healthy soils are essential for sustainable agriculture, particularly in managing plant diseases. They influence pathogen density, especially for soil-borne diseases, shape beneficial microbial communities, and affect the availability of nutrients for plant growth (Van Bruggen et al. 2016). However, over the past few decades, pollution from industrial emissions and agricultural waste, along with excessive chemical use for plant care and pest control, has led to significant and often irreversible declines in soil quality. This deterioration is characterized by soil compaction, loss of organic matter, mineral imbalances, and contamination from heavy metals and pesticides (Kosalec et al. 2009; Lu et al. 2015; Tripathy et al. 2015). Such declines in soil health can further weaken host plants' immunity to pathogen infections.

Agricultural management practices significantly affect soil quality (Bancal et al. 2008), which in turn influences disease occurrence. Strategies aimed at enhancing soil quality—such as increasing beneficial microorganisms and microbial biodiversity through organic matter addition—also contribute to reducing disease development (Page et al. 2013). Crop rotation, for instance, not only improves the physical and chemical properties of the soil, including nutrient balance, but also enhances the diversity of microbial communities (Ball et al. 2005). Conversely, practices like continuous cropping and monocultures raise the likelihood of disease outbreaks by enabling pathogens to build up high inoculum levels. This is particularly relevant for soil-borne diseases but also applies to many foliar diseases. Additionally, these practices can undermine disease management approaches that rely on a limited set of resistance genes or pesticides, as they create increased selection pressures on pathogens due to reduced host diversity and the frequent use of pesticides with similar modes of action (Sommerhalder et al. 2010).

Single and static management strategies increasing the intensity of plant disease outbreaks

Plant pathogens pose significant challenges for control due to their rapid spatio-temporal dynamics and swift evolution, characterized by high genetic diversity and short generation times. These factors enable them to overcome effective disease management strategies, particularly those relying on major R gene resistance and industrial pesticides (Strange and Scott 2005). Although integrated pest management (IPM) strategies were developed in the last century to tackle plant diseases using a combination of methods tailored to specific conditions, the reliance on chemical pesticides has dominated these strategies, especially for crops that lack major resistance (Guedes et al. 2015). Reports indicate that the increase in pesticide usage has outpaced food production growth in recent decades (Popp et al. 2013), highlighting a decline in the effectiveness and economic viability of pesticide-based disease management. Typically, pesticides are applied in a standardized manner—set types, timing, frequency, and dosages—without considering the specific resistance of the crop, environmental conditions, or the pathogen's sensitivity to chemicals. This rigid approach not only lowers management efficiency and raises costs but also leads to various negative impacts on the environment and society, including risks to human and animal health and ecological harm.

Challenges of plant disease management-rational management

Plant pathology is confronted with increasing challenges. On one hand, the global population is projected to reach 9 billion by 2050 (Godfray et al. 2010), leading to rising societal demands for abundant, high-quality, and diverse food. On the other hand, the availability of arable land is decreasing, and natural resources are being depleted, limiting the potential for boosting agricultural productivity (Ray et al. 2013). As we look to the future, there is a critical need for sustainable plant disease management strategies that not only ensure food security and promote societal progress but also minimize negative impacts on the environment and natural resources. Moreover, agricultural practices such as monocultures and intensification, which prioritize maximum yield through high inputs of fertilizers, water, and pesticides, contribute to the evolution and spread of plant diseases (Zhan et al. 2014, 2015).

Future plant disease management strategies should take into account three key components: society, economics, and ecology. The primary objective of these strategies is to provide safe and sufficient food for society, which is essential for ensuring food security and social stability. This involves increasing crop productivity, minimizing food contamination from microbial toxins, and ensuring a diverse and affordable food supply. From an economic perspective, it's crucial to assess the input-to-return ratio of plant disease management methods. This evaluation should include both direct and indirect economic benefits and costs, considering short- and long-term impacts, as well as externalities and opportunity costs. In terms of ecology, plant disease management should leverage ecological principles to mitigate disease outbreaks by modifying agricultural practices. Additionally, it is important to evaluate how these strategies affect the sustainability of both agriculture and the broader ecological environment.

The ecological way to rational management of plant disease

The foundation of sustainable plant disease management lies in creating an agro-ecological system that supports plant growth and development while hindering pathogen evolution and the spread of epidemics. This approach relies on understanding the interactions among plants, pathogens, vectors, and the environment (Acosta-Leal et al. 2011). Host resistance is considered the most effective and practical method for managing plant diseases. This resistance can be either induced or constitutive, and can manifest in a systematic or local manner, as well as being qualitative or quantitative. Most of the resistance traits found in crops are derived from landraces or wild relatives through plant breeding (Manosalva et al. 2015; Palmgren et al. 2015). While qualitative (or major gene) resistance is highly effective, it often becomes less effective due to the rapid evolution of plant pathogens driven by modern agricultural practices (Thrall et al. 2012). As a result, many qualitative resistance traits can lose their efficacy within just a few years after being commercially introduced, especially when deployed in large-scale monocultures.

Disease avoidance focuses on creating a mismatch between the critical phases of crop and pathogen development by altering the cultivation patterns of host plants. This can be achieved through changes in planting time, planting location, or the cultivation system employed. Elimination strategies involve methods that remove overwintering sites and hosts of pathogens, as well as their transmission vectors, leading to significant improvements in plant disease management with minimal ecological impacts by reducing or eradicating inoculum sources. However, a major challenge in implementing an elimination strategy is accurately identifying the correct sources of primary inoculum. Misidentifying these sources can diminish management effectiveness and waste resources. If a disease continues to cause epidemics year after year despite extensive human intervention, it is essential to reassess whether the critical points in the disease cycle have been correctly identified, evaluate the feasibility of eradicating those points, and rethink the overall management strategies.

Remedying plant diseases often involves the application of pesticides to eliminate pathogens and their insect vectors, especially when other methods fail to sufficiently reduce pathogen populations and mitigate epidemics. However, in an integrated disease management system, the goal of pesticide use is not to completely eradicate the disease but to manage it within acceptable limits defined by ecological and economic thresholds. When applying pesticides, it's important to take into account factors such as their modes of action and the potential for pathogen resistance (Siegwart et al. 2015).

The future of plant disease management

Sustainable plant disease management necessitates a comprehensive approach that considers the economic, social, and ecological impacts of various management strategies. This involves a deep understanding of the mechanisms behind plant disease epidemics, the functioning of healthy agro-ecosystems, and the individual and collective roles of RAER (Resistance, Avoidance, Elimination, and Remedy) approaches in disease management. The goal of this model is not only to enhance agricultural productivity and improve food quality but also to safeguard the ecological environment and natural resources. To achieve these objectives, future research in ecological plant disease management should prioritize: (i) studying the patterns of epidemics and evolution of plant diseases in response to changing environments and agricultural practices; (ii) examining the role of ecological factors in agricultural productivity and crop health; (iii) conducting socio-economic analyses of plant disease epidemics and their management; and (iv) developing technologies that integrate major crop disease management with ecological principles.

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AGRIBUSINESS MANAGEMENT: PAVING THE WAY FOR SUSTAINABLE GROWTH IN AGRICULTURE

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Introduction

Agriculture forms the cornerstone of many economies around the world, particularly in developing countries, where it plays a vital role in supporting livelihoods and ensuring food security. In these regions, a significant portion of the population relies on agriculture not just as a source of income, but also as a means of sustaining communities and cultures. As global challenges like population growth and climate change intensify, the agricultural sector faces increasing pressure to adapt and evolve. With the world's population projected to soar to nearly 9.7 billion by 2050, the demand for food, fiber, and other agricultural products will continue to rise. This increasing demand, combined with limited natural resources, underscores the urgent need for sustainable agricultural practices that can deliver more with less. Here, agribusiness management emerges as a pivotal solution that marries traditional farming techniques with modern business practices, resulting in enhanced productivity, profitability, and resilience.

Agribusiness management involves not just growing crops or raising livestock but also encompassing a wide range of activities that span from input supply to food processing, distribution, and marketing. It's about transforming agriculture into a dynamic and adaptable enterprise that can withstand and respond to market fluctuations, environmental concerns, and resource limitations. By applying business principles to agriculture, agribusiness management seeks to make agricultural enterprises more competitive, efficient, and sustainable.

In essence, agribusiness management enables farmers and agricultural enterprises to optimize their resources, improve financial performance, and embrace technological innovations. These capabilities are essential for achieving sustainable growth in agriculture, as they allow agribusinesses to not only meet the current demand but also prepare for future challenges. Through strategic planning, effective resource management, and the use of modern technology, agribusiness management contributes to the long-term sustainability of agriculture, ensuring that it remains a viable source of livelihood and a crucial part of the global economy.

Agribusiness management is more than just growing crops or raising livestock; it's about transforming agriculture into a well-coordinated and efficient enterprise. At its core, agribusiness management involves planning, organizing, and controlling various agricultural processes to optimize production and enhance profitability. This field blends agricultural practices with business principles, enabling agribusinesses to streamline operations, reduce costs, and adapt to changing market dynamics. By doing so, agribusiness management contributes to building a robust foundation for food security and sustainable growth in agriculture.

The scope of agribusiness management extends beyond traditional farming activities, encompassing a broad range of areas. These include farm input supply, food processing, packaging, distribution, and marketing. Such a holistic approach ensures that every step of the agricultural value chain is managed effectively, from the initial stages of production to the delivery of products to consumers. Furthermore, modern agribusiness management heavily relies on data-driven decision-making, employing technology and analytics to minimize risks and make resource optimization a reality.

Key Components of Agribusiness Management

Agribusiness management can be broken down into several key components, each playing a crucial role in ensuring the efficiency and profitability of agricultural enterprises. Here's a closer look at these components:

1. **Farm Management:** Farm management is the foundation of any successful agribusiness. It involves strategic decisions related to crop selection, soil management, irrigation, pest control, and labor allocation. Agribusiness managers must carefully plan and execute these tasks to maximize yields while keeping costs under control. Through efficient farm management, they can optimize production inputs like water, fertilizers, and seeds, which ultimately leads to enhanced productivity and profitability.
2. **Supply Chain Management:** A well-functioning supply chain is critical to ensuring that agricultural products reach consumers efficiently. Agribusiness managers oversee the supply chain, which includes storage, logistics, and distribution. Effective supply chain management minimizes product wastage, maintains quality, and guarantees that products are delivered to markets in a timely manner. By ensuring a smooth flow from farm to table, agribusinesses can reduce costs, increase customer satisfaction, and maintain competitive advantages.
3. **Financial Management:** Financial management is essential for the longevity and sustainability of agribusinesses. It involves budgeting, investment analysis, risk management, and securing access to credit. Effective financial management helps agribusinesses maintain a healthy cash flow, which is crucial for operational stability and growth. By carefully managing finances, agribusiness managers can allocate resources for modernization, invest in new technologies, and seize opportunities for expansion.
4. **Marketing and Sales:** Marketing is a key determinant of success in agribusiness. Managers must identify target markets, understand consumer preferences, and develop marketing strategies that resonate with customers. Effective marketing and sales efforts allow agribusinesses to build relationships with stakeholders such as retailers, wholesalers, and end consumers. By doing so, they can enhance brand recognition, expand their market reach, and drive sales.
5. **Human Resource Management:** The agricultural sector relies heavily on human resources, from field laborers to management staff. Human resource management ensures that agribusinesses have access to a skilled, motivated, and well-trained workforce. This involves recruiting, training, and retaining employees, as well as ensuring fair wages and safe working conditions. A well-managed workforce is more productive, which in turn enhances the overall performance of the agribusiness.

6. **Use of Technology:** The integration of technology has revolutionized agribusiness management. Technologies such as precision agriculture, drones, IoT devices, and data analytics enable agribusiness managers to make informed, data-driven decisions. These tools help monitor crop health, predict weather patterns, optimize resource usage, and forecast market trends. By leveraging technology, agribusinesses can increase efficiency, reduce waste, and adapt to changing environmental conditions, paving the way for more sustainable agricultural practices.

Challenges in Agribusiness Management

While agribusiness management offers numerous advantages for enhancing productivity and sustainability, it is not without its challenges. Agribusiness managers often face a range of issues that can hinder growth and profitability. Here's a closer look at some of the primary challenges and potential strategies to address them:

1. **Fluctuating Market Prices:** Agricultural markets are highly volatile, with prices influenced by a variety of factors such as weather conditions, global supply and demand, political instability, and changes in consumer preferences. These price fluctuations can significantly impact the profitability of agribusinesses, especially for small-scale farmers who lack the resources to absorb financial shocks. To cope with this, agribusiness managers can diversify their income sources by exploring alternative markets, growing multiple types of crops, or even venturing into agritourism or other farm-based activities. Diversification reduces dependency on a single income stream, thereby lessening the impact of market volatility.

2. **Climate Change:** Climate change poses a serious threat to agriculture, as it can lead to unpredictable weather patterns, extreme temperatures, and an increase in the frequency and severity of natural disasters. These changes can devastate crops, reduce yields, and increase pest and disease pressures. To address these risks, agribusinesses can invest in climate-smart practices such as water-saving irrigation techniques, soil conservation, crop diversification, and the use of drought-resistant crop varieties. Additionally, utilizing climate data and forecasting tools can help agribusiness managers plan and adapt their operations to changing environmental conditions.
3. **Resource Scarcity:** Agriculture relies heavily on natural resources, including water, soil, and energy. However, the increasing scarcity of these resources, coupled with rising competition for their use, poses a challenge for sustainable agricultural practices. Agribusiness managers must prioritize resource optimization and explore alternative solutions. For example, adopting precision agriculture techniques can help minimize water and fertilizer usage, while renewable energy sources such as solar or wind power can reduce dependency on fossil fuels. Furthermore, recycling agricultural waste and implementing efficient waste management practices can contribute to conserving resources and reducing environmental impact.
4. **Limited Access to Financing:** Financial constraints are a common challenge for agribusinesses, particularly for small and medium-sized enterprises (SMEs) that may have limited access to traditional financing options. Without adequate funding, these businesses struggle to invest in new technologies, expand their operations, or manage cash flow during low-income periods. To overcome these challenges, agribusiness managers can explore alternative financing options such as microloans, crowdfunding, and partnerships with agricultural cooperatives or non-governmental organizations (NGOs). These financing avenues can provide access to the necessary capital while reducing dependency on traditional banking systems, which may have stringent requirements or high-interest rates.
5. **Labor Shortages:** Labor shortages are increasingly affecting the agricultural sector, particularly in regions where young people are migrating to urban areas in search of better job opportunities. This leaves a smaller workforce available for physically demanding agricultural tasks. Agribusiness managers can address this issue by investing

in mechanization and automation to reduce reliance on manual labor. Additionally, offering competitive wages, safe working conditions, and career development opportunities can help attract and retain workers.

6. **Regulatory Compliance:** Agribusinesses must comply with various regulations related to food safety, environmental protection, and labor laws. Navigating these regulations can be complex, time-consuming, and costly, particularly for smaller businesses. Staying informed about current regulations, investing in training, and adopting best practices for compliance can help agribusinesses mitigate potential legal risks and penalties. In some cases, collaboration with industry associations and advocacy for policy reform can also make it easier for agribusinesses to comply with regulations.
7. **Technological Barriers:** While technology can greatly enhance agribusiness operations, the adoption of advanced tools and equipment often requires significant investment and technical expertise. Additionally, the availability of internet connectivity and digital infrastructure may be limited in rural areas. To overcome these barriers, agribusiness managers can start with incremental technology upgrades and seek partnerships with technology providers, government agencies, or NGOs that offer training and support. Building digital literacy within the workforce is also essential for successfully integrating new technologies.

The Role of Agribusiness Management in Sustainable Agriculture

Agribusiness management is crucial for advancing sustainable agricultural practices. By emphasizing efficient resource use, waste reduction, and environmentally friendly approaches, agribusiness managers can actively work to reduce the environmental impact of agricultural activities. For instance, adopting precision agriculture techniques allows for the precise application of water, fertilizers, and pesticides, minimizing waste and protecting natural ecosystems. Additionally, promoting crop rotation, organic farming, and soil conservation techniques contributes to preserving biodiversity and maintaining soil health.

Integrating renewable energy sources such as solar and wind power into agribusiness operations is another significant step towards sustainability. By reducing reliance on fossil fuels, these renewable options help to lower greenhouse gas emissions, which is essential in the fight against climate change. For example, installing solar panels on farms can power irrigation systems or processing facilities, while wind turbines can supply energy to rural agribusinesses, decreasing operational costs and environmental impact.

Beyond environmental benefits, agribusiness management plays a pivotal role in promoting social sustainability. Agribusinesses often serve as major employers in rural areas, creating job opportunities that can uplift entire communities. By ensuring fair labor practices, offering competitive wages, and investing in employee training, agribusinesses contribute to the social welfare and economic stability of these communities. Furthermore, many agribusinesses engage in community development initiatives, such as supporting local schools or healthcare facilities, which strengthens social ties and fosters a positive relationship between the business and the community.

Economic sustainability is also a key component of agribusiness management. By implementing effective financial strategies, agribusiness managers can increase profitability, reduce waste, and enhance the competitiveness of agricultural enterprises. This, in turn, contributes to national economic growth by strengthening the agricultural sector, boosting exports, and providing stable income sources for rural populations. In this way, agribusinesses play a critical role in supporting broader economic goals while also ensuring their own long-term viability.

Conclusion

Agribusiness management is a dynamic and essential field that holds the potential to transform agriculture for the better. By embracing sustainable practices, agribusinesses can improve productivity, profitability, and environmental stewardship, helping to meet the growing global demand for food. As the challenges facing agriculture continue to evolve, the role of agribusiness management in promoting sustainable development will only become more important. With a focus on efficient resource use, renewable energy integration, and social responsibility, agribusiness management can shape a future where agriculture thrives in harmony with nature, providing food security and economic stability for generations to come.

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THE COLORFUL WORLD OF SORGHUM: UNDERSTANDING THE DIFFERENCES AND SIGNIFICANCE OF RED, YELLOW, AND WHITE VARIETIES

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Introduction

Sorghum, a resilient crop that has sustained civilizations for centuries, particularly in Africa, India, and other dry regions, comes in various colors with distinct nutritional value, taste, and applications. The most popular types include red, yellow, and white sorghum, each with unique qualities. Let's delve into the diverse world of sorghum and discover what makes each variety special.

"Red Sorghum (The Unrivaled Antioxidant Champion)":

Red sorghum is one of the most visually stunning sorghum varieties due to its deep red hue, attributed to natural pigments called anthocyanins, which are potent antioxidants. These compounds are crucial for human health as they combat free radicals, thereby reducing the risk of chronic diseases such as heart disease and cancer.

In terms of nutrition, red sorghum is packed with fiber and boasts a well-balanced profile of essential minerals including iron, magnesium, and phosphorus. Its whole-grain potential makes it an ideal choice for producing gluten-free flour used in baking. The strong antioxidant properties of red sorghum also make it a sought-after option for functional foods designed to promote health and well-being.

Uses of Red Sorghum:

- Red sorghum is often used in whole grain products, flours, and cereals.

- It’s highly sought after in the health food market due to its antioxidant content.
- It’s also used in animal feed, particularly for poultry, because of its high nutritional value.

"Yellow Sorghum (The Ultimate Energy Booster)":

Yellow sorghum is a nutrient powerhouse, containing high levels of essential vitamins, particularly vitamin A and beta-carotene, which gives it its vibrant golden hue. Vitamin A is crucial for maintaining healthy vision, a robust immune system, and overall cellular health, making yellow sorghum an excellent choice for addressing nutrient deficiencies, particularly in regions with food security challenges.

In terms of taste, yellow sorghum offers a slightly sweeter flavor compared to its red and white counterparts, making it a popular option for a wide range of food products, including porridges, baked goods, and even as a substitute for rice. It’s ideal balance of carbohydrates and proteins provides a substantial energy boost, making yellow sorghum a valuable ingredient in both human and livestock food.

Uses of Yellow Sorghum:

- Used in cereals, baked goods, and snack foods.
- Ideal for regions where vitamin A deficiency is a concern.
- Widely used in animal feed, particularly for cattle and poultry, because of its energy content and digestibility.

White Sorghum (The Neutral Hero):

White sorghum is a highly versatile and widely cultivated variety known for its mild flavor and suitability for gluten-free diets. Its flour produces light and airy baked goods similar to wheat flour, making it a popular choice in the growing gluten-free market. Additionally, white sorghum's lower tannin content results in a smoother, less bitter taste, allowing for its use in a wide range of food products including breads, porridges, and beverages. Its neutral color and flavor make it ideal for creating aesthetically pleasing light-colored breads, cakes, and beer.

Uses of White Sorghum:

- Primarily used in gluten-free flour for baked goods.
- Popular in beer brewing due to its neutral flavor.
- Used in livestock feed and food products where a mild flavor is desired.

Differences in Nutritional Value and Applications

Feature	Red Sorghum	Yellow Sorghum	White Sorghum
Color	Deep red, due to anthocyanin pigments	Golden yellow, due to beta-carotene	Pale or white
Nutritional Highlights	High in antioxidants (anthocyanins)	Rich in beta-carotene (precursor to vitamin A)	Low in tannins, neutral flavor
Taste	Slightly bitter due to higher tannin content	Slightly sweet	Mild, neutral taste
Common Uses	Whole grains, gluten-free flours, health foods	Livestock feed, porridges, baked goods	Gluten-free flour, light-colored baked goods, beer brewing
Health Benefits	Antioxidant-rich, good for heart health	Supports vision and immune health	Easily digestible, used for gluten-free diets
Industrial Applications	Functional foods, animal feed	Energy source for livestock, human food	Flour for baking, brewing, animal feed
Adaptation to Climate	Drought-tolerant, suitable for dry regions	Suitable for semi-arid and tropical climates	Grows well in varied climates, drought-tolerant

Sorghum's Importance in Food Security

The various colors of sorghum, including red, yellow, and white, play a crucial role in ensuring global food security. With the ongoing impact of climate change on food production, sorghum's drought tolerance and ability to thrive in harsh environments make it a dependable crop for both human consumption and animal feed.

Sorghum's capacity to flourish in arid, nutrient-poor soils makes it a fundamental crop in regions vulnerable to drought. In areas of Africa and Asia where food scarcity is a significant concern, the different sorghum varieties offer a sustainable solution. Additionally, with the increasing demand for gluten-free products worldwide, sorghum is gaining importance in Western diets.

Conclusion

Each sorghum variety—red, yellow, and white—offers unique benefits. The antioxidant-rich red sorghum, vitamin A-packed yellow sorghum, and versatile white sorghum provide significant nutritional and industrial advantages. In the face of global challenges such as food insecurity and climate change, sorghum emerges as a crucial crop that can fulfill both the nutritional needs of people and the demands of industry. Sorghum is not just a grain—it represents a solution. Whether you seek to enhance your health, meet dietary requirements, or engage in sustainable agriculture, the diverse nature of sorghum makes it a crop deserving of celebration.

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Sorghum and Millets in Human Nutrition (FAO Food and Nutrition Series, No. 27) – Offers details on sorghum's health benefits, especially in developing countries.

Review on Sorghum Grain: Nutrition, Uses, and Health Benefits (Published in "International Journal of Food Science") – A peer-reviewed paper focusing on the nutritional content and industrial applications of sorghum varieties.

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SUGARCANE: PROCESSING AND BYPRODUCT VALUE ADDITION

Article ID: AG-VO4-I10-41

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Introduction

Sugarcane is a key commercial crop in India. During 2022-2023, it was cultivated on 5,883 thousand hectares, yielding 494,228 thousand tonnes of sugarcane across India. The processing of sugarcane produces four primary byproducts: bagasse, filter cake, molasses, and cane tops. At harvesting and processing of sugarcane, approximately 120 kg of sugar, 38 kg of molasses, 36 kg of filter mud, 250 kg of bagasse, 60 kg of straw, and 100 kg of tops can be obtained for each ton of sugarcane harvested. Here are the details on the processing of sugarcane and its byproducts.

Sugarcane processing

After transportation to the production facility, the sugarcane is typically washed and directed to the broth preparation and extraction system, which consists of four to seven milling units. The broth is extracted, separating sugars from the fiber (bagasse), which is then sent to the energy plant of the production unit. To enhance extraction yields, the chopped and shredded cane undergoes multiple washes with hot water to extract additional sugars. Finally, the cane passes through a drying roller, producing bagasse for use in the boilers. The sugarcane juice obtained in the mill or diffuser can then be utilized to produce either sugar or ethanol. To produce sugar, the broth undergoes a series of treatment processes that involve both physical methods (such as sieving, heating, and flashing) and chemical reactions (facilitated by the addition of various chemicals and polymers). These steps aim to eliminate nonsugars, colloids, turbidity, and color while promoting sedimentation to maximize sucrose recovery and ensure a high-quality final product.

Following the chemical treatment, the broth is heated to sterilize it by eliminating microorganisms, completing reactions with the alkalizing agent, coagulating and flocculating insoluble impurities, and removing gases. The broth is then transferred to a decanter or clarifier, where the flocculated impurities, known as sludge, are separated. The clarified broth flows out from the top of the trays, which are now largely free of impurities. In the decanters, only the physical separation of the broth from the sludge occurs. The removed sludge is combined with bagasse and filtered to recover any remaining sucrose, while the residual filter cake is used as fertilizer in sugarcane fields.

The treated broth is then concentrated using multieffect evaporators and cookers for sucrose crystallization. During this process, not all the available sucrose from the cane is crystallized, and the residual sugary solution (molasses) may be returned to the process multiple times to extract more sugar. The final broth, known as molasses, does not go back into the sugar production process; however, it still contains some sucrose along with high levels of reducing sugars (glucose and fructose), making it suitable as a raw material for ethanol production through fermentation. Finally, the sugar is directed to the drying stage, where moisture levels are reduced through simultaneous cooling, allowing it to be stored for varying durations without significant changes in quality, thus maintaining its suitability for consumption as a food product.

Ethanol production

The initial stages of ethanol production closely resemble those of sugar production. After treatment, the cane juice is evaporated to adjust its sugar concentration and is then mixed with molasses to create the wort. This wort is transferred to fermentation units, where it is combined with yeasts (Saccharomyces cerevisiae) and fermented for about 6 to 10 hours, resulting in a fermented mixture known as wine, with an alcohol concentration of 7% to 10%. Following fermentation, the yeasts are recovered and prepared for reuse, while the wine is sent to distillation columns. This process offers economic benefits by allowing the reuse of yeasts in fermentation. Distillation serves as a physical method for separating components in a mixture based on their relative volatility.

Bagasse

Bagasse is the by-product generated from the extraction of sugarcane juice. Since it incurs minimal production and transportation costs, it is highly valued, particularly as a substitute for fossil fuels and wood in steam and electricity generation. This use promotes energy self-sufficiency for production units, and in some cases, allows for the sale of excess electricity. Additionally, bagasse is utilized in the production of cellulosic ethanol and furfural. Furfural serves as a solvent for refining lubricating oils, wood resins, and vegetable oils, while furfuryl alcohol is used as a raw material for furanic polymers, anticorrosives, urea polymers, modified formaldehyde, fragrances, and solvents for resins and dyes.

Molasses

From a technological perspective, molasses is the syrup that results from the final stage of crystallization, from which no additional sugar can be extracted through further crystallization. The syrup obtained after the first crystallization is typically referred to as A molasses. If evaporation and centrifugation are repeated to recover more sugar, the resulting syrup is known as B molasses.

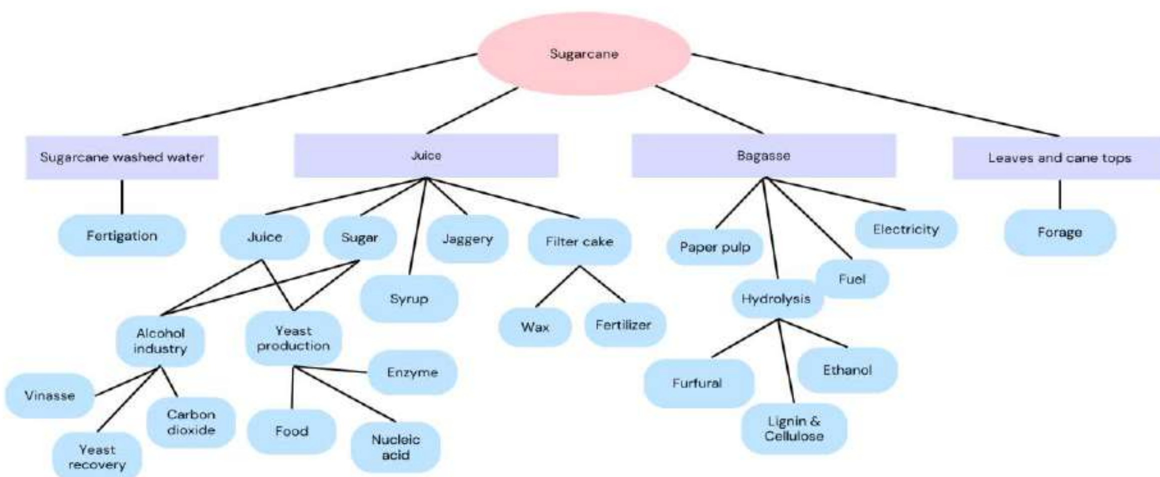
During sugar production, a by-product called residual molasses is generated, which can be categorized regionally as poor molasses, final molasses, or simply molasses. This dense, viscous liquid is dark brown in color, rich in sugars, and contains a small percentage of water. Its density ranges from 1.4 to 1.5 g/mL, produced at a rate of 40 kg per ton of cane, with an ethanol yield of 280 to 320 L per ton. The composition of molasses is influenced by various factors, including the cultivar, age, health status, maturation cycle, cultivation methods, fertilization, sugarcane treatments, and environmental conditions, as well as aspects related to sugar production, cane harvesting, and storage time.

Molasses is commonly used in ethanol production at distilleries associated with sugar mills, but it can also serve as animal feed or as a substrate for cultivating fungi and bacteria in other fermentation processes aimed at producing chemicals and pharmaceuticals, as well as biological yeast. In East Asian countries, molasses is extensively used in the fermentation process for producing monosodium glutamate, citric and formic acids, and amino acids like lysine.

Molasses powder offers an organoleptic, energetic, and flavor-enhancing supplement for animal feed, making it a direct input for cattle farmers and feed manufacturers. Its advantages over liquid molasses include ease of formulation for animal feed and improved transport, handling, and storage due to its plastic packaging. In contrast, liquid molasses presents transportation challenges, requiring special care and storage in tanks, and has a higher likelihood of fermentation. Additionally, molasses powder is utilized in steelmaking to coat molds for casting steel.

Vinasse

Vinasse is the final by-product from the distillation of fermentation wine used to produce ethanol. It has a brown color that darkens with oxidation when exposed to air. This by-product is a significant and concerning liquid effluent in the agro-energy industry. For every liter of ethanol produced, approximately 10 to 15 liters of vinasse are generated. The challenge associated with this volume of vinasse stems from the toxicity of ethanol to the yeasts employed, which necessitates lowering the alcohol content during the final stage of fermentation. As a result, the same volume of wine yields less ethanol and leads to an increase in the amount of vinasse produced.



Filter cake

Filter cake is defined as the by-product removed during the decanting of sugarcane juice in the treatment process for sugar and/or ethanol production. It can be produced through three main methods: rotary vacuum filtration, filter pressing, and diffuser separation. The chemical composition of the filter cake varies based on several factors, including soil type, cultivar, harvest method, juice extraction efficiency, lime dosage, and the clarification agents used, as well as the filtration techniques employed.

In most sugar and ethanol production facilities, filter cake is commonly utilized as fertilizer in sugarcane fields. This is its primary application, largely due to the significant amounts of nitrogen, phosphorus, calcium, and organic matter it adds to the soil. Additionally, filter cake can be processed to extract wax. In the agro-industrial process, only 40% of the lipid material from the cane is found in the broth, while the rest remains in the bagasse. About 95% of the lipids present in the broth are concentrated in the filter cake, which meets the quality standards needed for various industrial applications, making it valuable for the food, pharmaceutical, chemical, cosmetic, cleaning, and polishing industries.

Yeasts

Yeasts are heterotrophic, unicellular, and non-photosynthetic microorganisms that can metabolize anaerobically or aerobically. They are commonly found in various environments, including soil, powder, and fruits, and can be transported by wind and insects.

The composition of yeasts can vary based on several factors, such as the substrate used, yeast species, fermentation method, age of the cells, and drying conditions. Yeast products are not only high in protein but also rich in B vitamins (such as B1, B2, B6, pantothenic acid, niacin, folic acid, and biotin), minerals, and both macro and microelements, particularly selenium and dietary fiber. The most extensively studied yeast for ethanol production is *Saccharomyces cerevisiae*, noted for its nutritional profile, making it a key player in producing various products. Additionally, it is capable of fermenting sugars into ethanol with high efficiency, even under aerobic conditions.

Yeasts have significant industrial applications due to their ability to metabolize hexoses, pentoses, organic acids, and hydrocarbons, as well as their capacity to produce alcohol and heterologous proteins. They are also utilized commercially for generating alcohol and enzymes such as dehydrogenases, hexokinase, lactate dehydrogenase, glucose-6-phosphate dehydrogenase, coenzyme A, and various nucleosides. Moreover, yeasts can enhance growth and productivity in livestock, including cattle, pigs, and poultry, by positively influencing intestinal health.

Other by-products

Carbon dioxide (CO2) generated during ethanol fermentation is typically released into the atmosphere, but it can also be purified, deodorized, liquefied, and stored under pressure for various applications, including the production of soft drinks, dry ice, sodium bicarbonate, and effluent treatment. This CO_2 is of very high purity (approximately 99.9%) and originates biologically. In the industry, around 1 kg of CO_2 is produced for every liter of ethanol made. Facilities have been developed to capture and utilize this carbon dioxide, which is primarily used for carbonating beverages, creating inert atmospheres for welding, casting, fire extinguishing, refrigeration, as an aerosol propellant, for tertiary oil recovery, and for transporting solids via pipelines.

Biodegradable plastics, or bioplastics, are special polymers synthesized by bacteria from sugars and other carbon sources. They closely resemble synthetic polymers derived from petroleum but decompose much more easily in the environment. For example, while polyethylene terephthalate (PET) bottles, commonly used for soft drinks, can take over 200 years to degrade, and traditional plastics may take more than 100 years, biodegradable plastic resins can break down in about a year, benefiting from being produced from renewable resources like starch, sugars, or fatty acids.

Among the amino acids produced through sugar fermentation, lysine is particularly noteworthy, as its market is rapidly expanding due to its applications in various industries, including meat, food, and pharmaceuticals.

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STUDIES ON GENETIC IMPROVEMENT OF *Terminalia chebula* Retz.

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Introduction

The studies regarding genetic improvement of *Terminalia chebula* Retz. was carried out at Forest College and Research Institute, Mettupalayam, Tamil Nadu during 2023 - 2024.

A total of thirty Candidate Plus Trees (CPTs) of *Terminalia chebula* were selected from predominantly growing regions of North-East and South India *viz.*, Andhra Pradesh, Assam, Karnataka, Kerala, Maharashtra and Tamil Nadu by comparison check tree method. The trees were selected based on comparative superiority of selected trees for biometric attributes *viz.*, height, girth at breast height (GBH), clear bole height, crown width and number of branches.

A total of 5 trees were selected from each geographical location based on growth attributes within each state namely, Andhra Pradesh (coded as APTC 01, APTC 02, APTC 03, APTC 04, APTC 05), Assam (coded as ASTC 01, ASTC 02, ASTC 03, ASTC 04, ASTC 05), Karnataka (coded as KATC 01, KATC 02, KATC 03, KATC 04, KATC 05), Kerala (coded as KETC 01, KETC 02, KETC03, KETC 04, KETC 05), Maharashtra (coded as MHTC 01, MHTC 02, MHTC 03, MHTC 04, MHTC 05) and Tamil Nadu (coded as TNTC 01, TNTC 02, TNTC 03, TNTC 04, TNTC 05.

Among the thirty CPTs, KATC 02, TNTC 05, ASTC 04, KATC 01 and KETC 03 proved superiority in terms of biometric attributes *viz.*, height, girth at breast height (GBH), clear bole height, crown width and number of branches respectively.

The results indicated significant variations among the selected thirty CPTs of *T. chebula* with respect to fruit and seed physical, chemical and biochemical attributes. The fruit of TNTC 05 and seed of KATC 04 recorded consistent superiority for the chemical compositions investigated with particular emphasis to tannin.

However, the tannin content of fruit ranged from 222.45 mg/100 g to 423.82 mg/100g and it ranged from 43.87 mg/100 g to 262.34 mg/100 g in seed, phenol content in fruit ranged from 625.49 mg/100 g to 465.77 mg/100 g and it ranged from 369.97 mg/100 g to 563.33 mg/100 g in seed, the carbohydrate content varied between 786.73 mg/100 g and 603.71 mg/100 g in fruit and it varied from 295.03 mg/100 g to 491.28 mg/100 g in seed, the protein content ranged between 211.51 mg/100 g to 357.97 mg/100 g in fruit and 87.67 mg/100 g to 259.25 mg/100 g in seed.

Biochemical characterization

The biochemical characterization of the fruit extracts of *T. chebula* revealed that a total of sixteen different functional groups *viz.*, Alcohols, Alkenes, Azide, Alkyl and Aryl halides, Alkynes, Aromatic compounds, Aliphatic ether, Amides, Alkanes, Aldehydes, Carboxylic acid, Halo compounds, Ketones, Nitro compounds, Nitriles and Phenols were recorded from the selected thirty CPTs of *T. chebula*. The gallic acid content in the methanol extract of *T. chebula* ranged from 0.098-2.949 g/100 g and ASTC 02 recorded the highest gallic acid content. The ellagic acid content ranged from 0.076-3.507 g/100 g with highest ellagic acid content recorded in ASTC 05.

The biometric observations indicated a wide range of variability among the progenies of thirty selected CPTs. The progenies of APTC 04, KETC 05 and MHTC 03 were proved as good performers based on superior biometric observations compared to other progenies.

The association studies between fruit and seed physical attributes and tannin content revealed that fruit curve width, seed roundness and seed aspect ratio exhibited positive correlations with tannin content, indicating a potential association. The remaining fruit and seed physical attributes showed either negative or non-significant correlations with tannin content, suggesting that these traits are not closely related to the tannin content in the studied genetic resources.

Correlation Coefficients

The genotypic correlation coefficients were higher than the phenotypic correlation coefficients for most of the fruit and seed physical attributes investigated and thus indicating the less environmental effect and true representation of the genotype. With respect to biometric attributes of seedlings, root: shoot ratio, root fresh weight and sturdiness quotient exhibited maximum positive correlation with quality index both at phenotypic and genotypic levels.

Path Co-efficient Analysis

The path co-efficient analysis revealed that multiple fruit and seed physical attributes significantly influenced tannin content, with fruit perimeter and seed perimeter having the strongest direct effects. Indirect effects were also significant, indicating complex interactions among these attributes in determining tannin content. The path analysis for biometric attributes of seedling revealed that various biometric attributes significantly influenced the quality index with root fresh weight, shoot fresh weight and volume index having the strongest direct effects.

Diversity Analysis

The diversity analysis of thirty progenies of *T. chebula* resolved them into ten clusters based on biometric attributes. Among the ten clusters, the cluster II was the largest with eight progenies (APTC 02, ASTC 03, KATC 02, KATC 03, KETC 04, KETC 05, MHTC 01 and TNTC 05) whereas the clusters V, VII, VIII, IX and X were the smallest with only one progeny each. Among the ten clusters, maximum inter cluster distance was recorded between clusters VI and cluster VIII (98.23) which decipher that they are genetically distant.

Conclusion

Cleft grafting was adopted to standardize the protocol for mass multiplication of elite genotypes of *T. chebula.* The highest graft success percentage was observed during the month of July (67.2%) whereas, the lowest success percentage was observed during the month of May (50.8%). Holistically, the highest graft success percentage (25.71%), survival percentage (76.4%), plant height (29.8 cm) and number of sprouts per grafted plant (8) were observed in the diameter class 0.6-0.8 cm during the month of July.

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GENETIC VARIABILITY IN PLANT BREEDING

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Introduction

Genetic variability is a key component of plant breeding, influencing the production of new cultivars and increasing agricultural productivity. This variability, also known as genetic diversity, refers to the differences in DNA sequences between individuals within a species. Understanding and harnessing genetic diversity is critical for increasing plant attributes like yield, disease resistance, and stress tolerance.

Sources of Genetic Variability

1. Mutations:

Mutations are spontaneous changes to an organism's DNA sequence. They can be produced by errors in DNA replication or environmental factors like radiation and chemicals. Mutations in plants can result in either new traits or modifications on existing ones. For example, the identification of mutant wheat types with changed gluten concentration has been critical in producing novel bread-making cultivars.

2. Genetic Recombination:

Recombination is the exchange of genetic material between homologous chromosomes during sexual reproduction. This process produces offspring with abilities that differ from those of their parents. Genetic recombination promotes variety and is an important mechanism for developing new plant varieties with specific characteristics. For example, recombination in maize has resulted with significant increases in yield and disease resistance.

3. Gene Flow:

Gene flow refers to the transmission of genetic material between populations or species via mechanisms like pollen dispersal and seed migration. This movement delivers new genetic variants into populations, potentially increasing adaptation. In crops such as rice and soybeans, gene flow has been used to transmit desirable traits from wild relatives into cultivars.

4. Polyploidy:

Polyploidy refers to having more than two sets of chromosomes. It can result from errors in cell division or hybridization. Polyploid plants are known for their increased growth, vigor, and disease resistance. Many key crops, such as wheat and potatoes, are polyploid, which helps to explain their high productivity.

5. Hybridization:

Hybridization is the cross-breeding of genetically distinct plants to create offspring with a variety of characteristics. This method can produce hybrids with enhanced characteristics, such as higher yield or insect resistance. Hybrid kinds of crops such as tomatoes and corn frequently exceed their parent lines due to hybrid vigor, also known as heterosis.

Significance in Plant Breeding

1. Trait Improvement:

Genetic variability enables breeders to improve specific characteristics such as yield, disease resistance, and quality. Breeders may generate varieties that better satisfy agricultural demands by choosing and cross-breeding plants with favorable characteristics. For example, the development of drought-resistant maize varieties has been critical to sustaining productivity in arid areas.

2. Disease and Pest Resistance:

Crop species require genetic variability to build tolerance to diseases and pests. Varieties with various genetic backgrounds are less likely to be equally sensitive to diseases. Breeders employ genetic variability to introduce resistance genes from wild relatives or other sources into cultivated types, so increasing their resilience.

3. Adaptation to Environmental Changes:

As climate change and environmental conditions change, genetic variability provide a pool of characteristics from which to select for enhanced adaptation. Breeders can find and incorporate characteristics like heat tolerance and salt tolerance to create crops that thrive in new environments. For example, breeding initiatives have created heat-tolerant rice cultivars for areas with rising temperatures.

4. Genetic Resources Conservation:

Maintaining genetic diversity is critical for agriculture's long-term viability. Conserving different genetic resources ensures that future breeding programs have access to a wide range of traits and are adaptable to changing situations. Seed banks and genetic repositories serve an important role in preserving plant genetic diversity for future generations.

Methods in Utilizing Genetic Variability

1. Marker-Assisted Selection (MAS):

MAS use molecular markers to identify and select plants with desirable characteristics more effectively than traditional approaches. By connecting specific genetic markers with characteristics, breeders can screen vast populations and choose individuals with the best gene combinations. This method expedites the breeding process and improves trait selection.

2. Genomic Selection:

Genomic selection is the process of estimating a plant's breeding value using genomic information. This strategy use high-density genetic markers for assessing individual performance and select the best prospects for breeding. Genomic selection is especially useful for complex characteristics regulated by numerous genes, and it can considerably accelerate the generation of novel kinds.

3. CRISPR/Cas9 and Genetic Engineering:

CRISPR/Cas9 technology allows for precise editing of the plant genome to introduce or modify specific characteristics. This approach enables targeted alterations in genes related with desirable characteristics, like as disease resistance or improved nutritional content. Genetic engineering, particularly the use of CRISPR/Cas9, has the ability to develop novel characteristics while also improving existing ones with high precision.

4. Genotype-by-Environment Interaction Studies:

Understanding how different genotypes respond to diverse environmental situations is critical for designing robust crops. Genotype-by-environment interaction studies assist breeders in determining how genetic diversity affects plant performance across a variety of conditions. This knowledge informs the selection of cultivars that are best suited to particular situations.

5. Sustainable Breeding Practices:

Implementing sustainable techniques in plant breeding is critical for reducing environmental impact and increasing long-term agricultural viability. This includes adopting conservation tillage, organic techniques, and incorporating genetic variety to improve crop resilience and reduce dependency on chemical inputs.

Challenges and Future Directions

1. Genetic Erosion:

Genetic erosion, or the loss of genetic variety among crop species, is a critical concern. Modern agricultural techniques, such as using a small number of high-yielding cultivars, can reduce genetic diversity. Addressing genetic erosion necessitates collaborative efforts to maintain and exploit varied genetic resources.

2. Ethical and Regulatory Issues:

The application of genetic engineering and biotechnology in plant breeding presents ethical and regulatory issues. Public acceptance, environmental safety, and the possible influence on non-target creatures are all important factors. Ensuring clear and rigorous regulatory frameworks is critical for resolving these concerns and encouraging responsible innovation.

3. Climate Change Adaptation:

Climate change poses an urgent challenge to plant breeding, necessitating the production of cultivars that can tolerate adverse conditions, shifting insect dynamics, and altered growth environments. Breeding for climate resilience entails combining varied genetic characteristics and leveraging new technology to successfully address these concerns.

4. Integration of Traditional and Modern Approaches:

Combining traditional breeding approaches with cutting-edge technology like genomics and gene editing can improve the efficiency and effectiveness of plant breeding initiatives. Integrating these approaches enables breeders to attain the best results by combining conventional practices with cutting-edge tools.

Conclusion

Plant breeding relies on genetic variability to generate improved crop types with desirable characteristics. Breeders can solve challenges like disease resistance, environmental adaptation, and sustainable agriculture by understanding and leveraging the sources of genetic variability. Modern technologies, such as marker-assisted selection, genomic selection, and gene editing, provide effective tools for harnessing genetic variation and increasing plant breeding. However, difficulties such as genetic erosion, ethical considerations, and climate change adaptability must be addressed to maintain plant breeding programs' long-term success and sustainability. The blending of traditional and modern approaches will be critical in meeting the future needs of global agriculture and ensuring food security.

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UNLOCKING PLANT POTENTIAL: EXPLORING BIOSTIMULANTS, THEIR TYPES, AND THEIR BENEFITS

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Abstract

Biostimulants are a diverse group of substances and microorganisms that promote plant growth and development beyond conventional nutrients, soil improvers, or pesticides. These include humic substances, hormone-containing products, amino acids, seaweed extracts, and chitosan. Biostimulants enhance nutrient uptake, stress tolerance, and overall plant health, thereby improving crop quality traits such as nutritional value, yield, and shelf life. They influence plant physiology by stimulating root development, enhancing microbial activity, and boosting antioxidant activity. Their application leads to optimized plant metabolic processes, increased resilience to abiotic stress, and sustainable agricultural practices, making them vital tools for modern farming. Biostimulants optimize metabolic processes, increase yield, and enhance plant resilience to abiotic stress, contributing to sustainable agriculture.

Key words: Biostimulant, Sustainable agriculture, Tolerance.

Introduction

The term "biostimulant" was coined by horticulture specialists to describe the substances that promote plant growth without being classified as nutrients, soil improvers, or pesticides. According to Zhang and Schmidt, biostimulants are materials that, in minute quantities, promote plant growth. Biostimulants come in various formulations with different ingredients, but they are generally classified into three major groups based on their source and content: humic substances

(HS), hormone-containing products (HCP), and amino acid-containing products (AACP) as it is shown in fig 1 and 3. The "First World Congress on the Use of Biostimulants in Agriculture," held in Strasbourg in November 2012, is regarded as a milestone in the acceptance of biostimulants into the academic field.

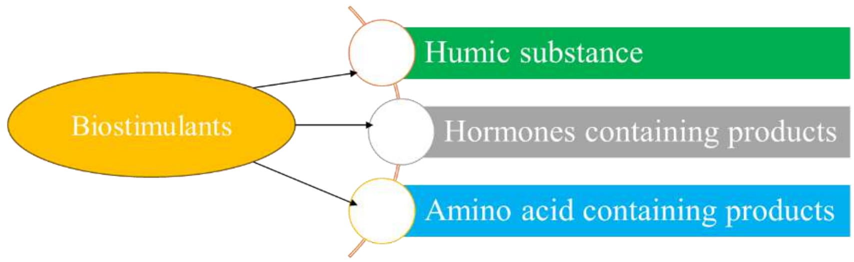

Fig 1: Major biostimulants

Common features of biostimulants:

Biostimulants are natural or synthetic substances that enhance plant growth and development by improving nutrient uptake, stress tolerance, and overall plant health, common feature of biostimulants is shown in fig 2.

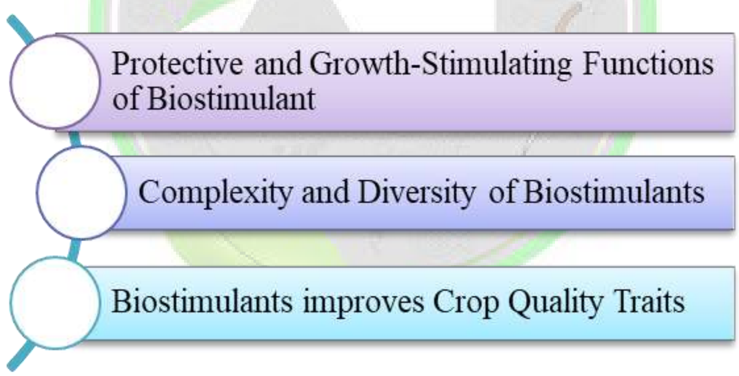

Fig 2: Common feature of biostimulant.

Protective and Growth-Stimulating Functions of Biostimulant:

Biostimulants perform a variety of physiological functions, including the protection of the photosynthetic apparatus against photo damage and the stimulation of lateral root formation. These functions are underpinned by cellular mechanisms, such as the scavenging of reactive oxygen species by antioxidants and the increased synthesis of auxin transporters.

Complexity and Diversity of Biostimulants

The nature of biostimulants is highly diverse, encompassing both substances and microorganisms. These substances can be individual compounds, such as glycine betaine, or complex groups of compounds derived from a single natural source, like seaweed extracts, whose precise composition and bioactive components remain partially characterized.

Impact of Biostimulants on Crop Quality Traits

Biostimulants contribute to at least one or several key agricultural functions, including enhanced nutrient use efficiency, improved tolerance to abiotic stress, and elevated crop quality traits. These quality traits may encompass nutritional value, grain protein content, and shelf life, among others.

Types of Biostimulants:

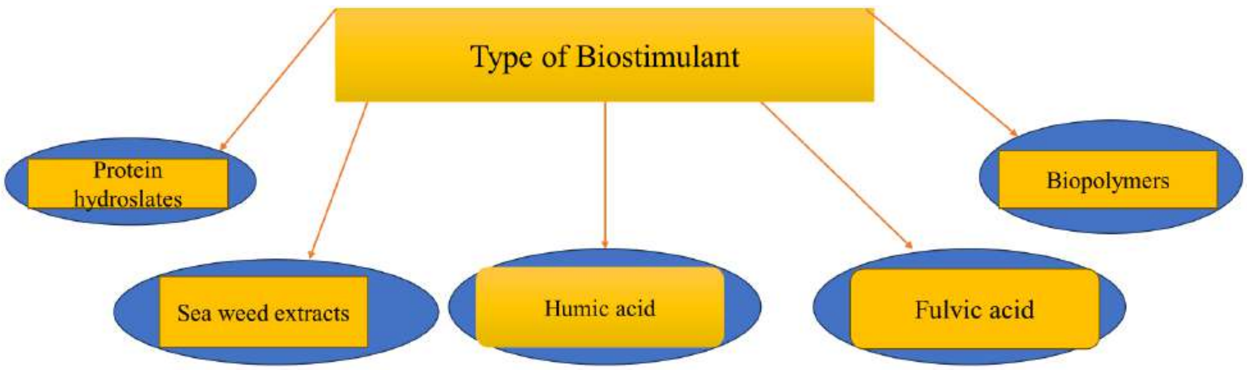

Fig 3: Types of biostimulant

Humic and fulvic acids:

Humic substances (HS) are a diverse group of compounds that are categorized based on their molecular weights and solubility into three main types: humins, humic acids, and fulvic acids. These substances undergo complex processes of association and dissociation in soil, forming supramolecular colloids. This dynamic is influenced by plant roots, which release protons and exudates. The creation of humic substances and their complexes in the soil results from the interactions among organic matter, microorganisms, and plant roots (du Jardin, 2012). HS can be extracted from naturally decomposed organic materials, such as peat or volcanic soils, as well as from composts, vermicompost, and mineral deposits like leonardite, which is an oxidized form of lignite. Humic substances play a crucial role in enhancing soil fertility by influencing the physical, physicochemical, chemical, and biological characteristics of the soil.

One key role of HS in root nutrition is the stimulation of plasma membrane H^+ATPases, which convert the free energy from ATP hydrolysis into a transmembrane electrochemical potential, facilitating the uptake of nitrate and other nutrients. In addition to nutrient uptake, proton pumping by plasma membrane ATPases also aids in cell wall loosening, cell enlargement, and organ growth (Jindo *et al*., 2022). HS are also associated with stress protection as shown in fig 5.

Fulvic acid, a type of humic substance, is widely acknowledged for its effectiveness as a biostimulant. Its small molecular size and high solubility enable it to penetrate plant cells easily, enhancing nutrient uptake. Fulvic acid promotes plant growth and health through several mechanisms. It chelates nutrients, making them more accessible for absorption by plant roots, which increases nutrient use efficiency and supports better growth and development. Additionally, fulvic acid interacts with soil particles, improving soil structure, which enhances water retention, aeration, and root penetration, as illustrated in Figure 4. It also encourages the growth of beneficial soil microorganisms, aiding in nutrient cycling and suppressing diseases. Furthermore, fulvic acid enhances plants' resilience to abiotic stresses such as drought, salinity, and extreme temperatures by boosting antioxidant activity and improving water use efficiency.

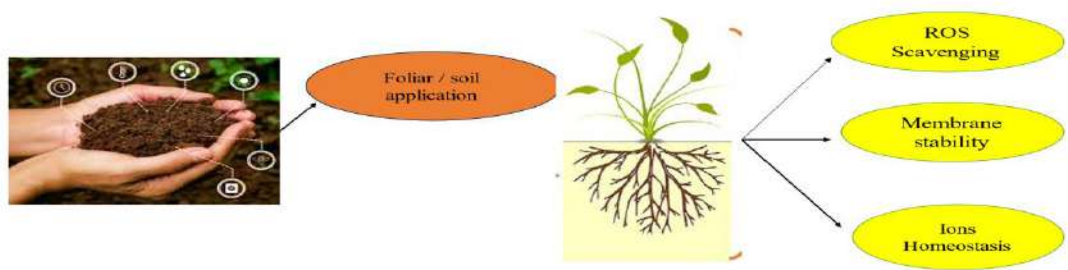

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Fig 4: Humic acid and its benefits.

Mechanisms by Which HS Affect Nutrient Uptake:

Humic substances improve plant nutrition by influencing soil processes and directly affecting plant physiology. Their impact on soil processes includes: (1) enhancing soil structure and (2) increasing the solubility of micronutrients within the soil. The direct physiological effects on plants involve: (3) modifying root morphology, (4) increasing the activity of root H^+ ATPase, and (5) enhancing the activity of nitrate assimilation enzymes.

Impact of Humic Acids on Plant Growth, Yield, and Nutrient Uptake

Humic acids, or humic substances, have been shown to enhance various aspects of plant growth across over 16 species, including major crops such as soybean, wheat, rice, and maize, as well as vegetables like potato, tomato, cucumber, and pepper, and fruits like citrus (*Citrus limon*) and grape (*Vitis vinifera*). One of the most common initial effects of humic acids is the promotion of root system development. For example, in tomatoes, humic acid applications lead to increased lateral root formation and improved seedling root growth. In addition to fostering early root development, humic acids have been demonstrated to increase both yield and crop quality

Protein hydrolysates and other N-containing compound:

Protein hydrolysates (PHs) are a category of plant biostimulants consisting of mixtures of polypeptides, oligopeptides, and amino acids, produced through partial hydrolysis of protein sources. These amino acids and peptide mixtures are obtained by chemically or enzymatically hydrolyzing proteins derived from agro-industrial by products, which include both plant sources (like crop residues) and animal waste as shown in fig 5. Among these nitrogenous compounds are betaines, polyamines, and "non-protein amino acids," which, though diverse in higher plants, remain poorly understood in terms of their physiological and ecological roles.

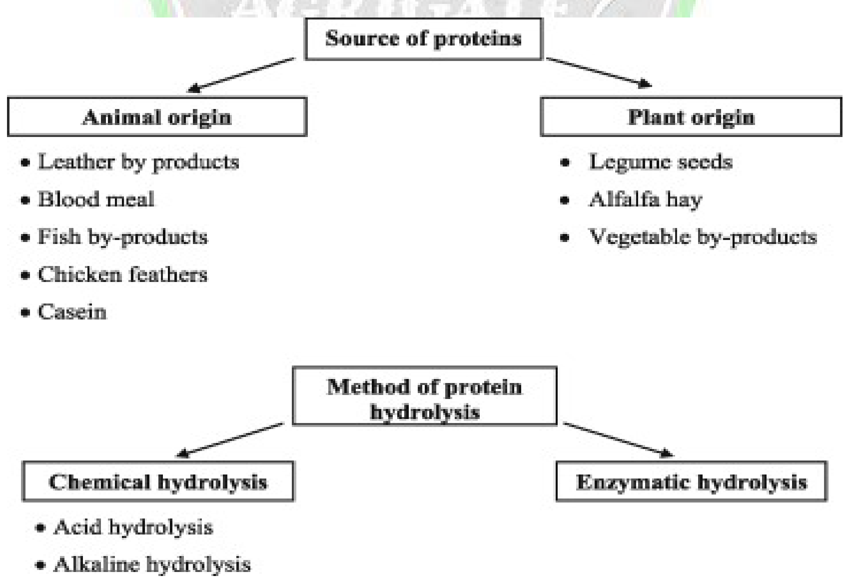

Fig. 5: Classification criteria of protein hydrolysates on the basis of protein source and the method of protein hydrolysis

One notable amino acid derivative, glycine betaine, is recognized for its anti-stress properties. It directly influences plants by modulating nitrogen uptake and assimilation through the regulation of enzymes involved in nitrogen metabolism, their structural genes, and the signalling pathways controlling nitrogen acquisition in roots. Additionally, glycine betaine helps regulate enzymes in the TCA cycle, thus contributing to the interaction between carbon and nitrogen metabolisms. Protein hydrolysates are also known to improve soil health by enhancing microbial biomass, activity, and soil respiration. Numerous commercial products made from protein hydrolysates of both plant and animal origins are available in the market, with many showing variable but often significant improvements in yield and quality traits of agricultural and horticultural crops (Calvo *et al*., 2014).

How Amino Acids Enhance Nutrient Uptake

The application of amino acids can boost plant nutrition by influencing soil processes and directly impacting plant physiology. Mechanisms affecting soil processes include: (1) promoting beneficial microbial communities and nutrient mineralization, and (2) enhancing micronutrient solubility through chelation and reduction. Direct physiological impacts on plants involve: (3) improving micronutrient mobility within the plant, (4) altering root morphology, and (5) increasing the activity of nitrate assimilation enzymes.

Seaweed extracts and botanicals

Botanical extracts (BEs) from both higher and lower plants, have demonstrated significant potential as biostimulants in agriculture. The regular use of plant-based products has been shown to enhance nutrient uptake, promote plant growth, improve tolerance to various environmental stresses, strengthen defense mechanisms, and boost crop productivity. BEs contain beneficial compounds such as polysaccharides, polyphenols, macro- and micronutrients, vitamins, fatty acids, and phytohormones, which contribute to the growth and development of many economically important crops. These extracts also help mitigate stress-induced oxidative damage, improve post-harvest quality, and increase overall agricultural yields. Common examples of plant-derived biostimulants include leaf extracts of *Moringa oleifera* Lam., powdered preparations of *Medicago sativa* L., and seaweed-based liquid sprays.

The use of fresh seaweeds as a source of organic matter and fertilizer has a long history in agriculture. Most of the algae used belong to the phylum of brown algae, with main genera including Ascophyllum, Fucus, and Laminaria as shown in table 2 . However, carrageenans are derived from red seaweeds, which belong to a different phylogenetic lineage. Seaweeds exert beneficial effects on soils and plants (Craigie, 2011) as shown in Table 1and fig 6. They can be applied to soils, used in hydroponic solutions, or administered as foliar treatments. In soils, their polysaccharides contribute to gel formation, water retention, and soil aeration. The polyanionic compounds in seaweeds aid in the fixation and exchange of cations, which is beneficial for the immobilization of heavy metals and soil remediation. In plants, seaweeds provide micro- and macronutrients, acting as fertilizers in addition to their other roles. Their impact on seed germination, plant establishment, and subsequent growth and development is associated with their hormonal effects, which are considered a major factor in their biostimulant activity on crop plants, the effects of sea weed extract on plant physiological process is shown in fig 4 and Table: 1.

Table 1: Effect of seaweed extract biostimulants on major crops (Ali *et al*., 2021).

Crop	Seaweed Extract	Effects
Tomato	*Ascophyllum nodosum*	Increased germination rate and seedling vigor
Sweet pepper	*A. nodosum*	Increased shoot and root growth
Lettuce	*Durvillaea potatorum*	Increased chlorophyll content
Cauliflower	*A. nodosum*	Increased heart size

Mechanisms of Nutrient Uptake Enhancement by SE

SE enhances plant nutrition by influencing soil processes and directly affecting plant physiology. The mechanisms impacting soil processes involve: (1) improving soil structure, and (2) increasing micronutrient solubility in the soil. Direct physiological effects on plants include: (3) altering root morphology, and (4) boosting root colonization by arbuscular mycorrhizal fungi.

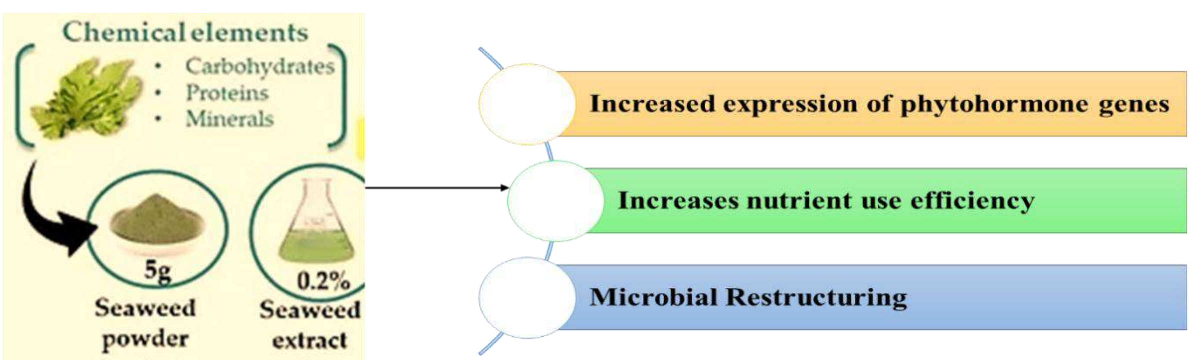

Fig 6: Benefits of using Sea weed extract as biostimulant.

Table 2: List of important seaweed species with biostimulatory activities (Ali *et al*., 2021).

Phaeophyceae	Rhodophyta	Chlorophyta
Ascophyllum nodosum	*Macrocycstis pyrifera*	*Ulva lactuca*
Ecklonia maxima	*Porphyra perforate*	*Enteromorpha prolifera*
Durvillea antarctica	*Nereocystis* spp	*Caulerpa paspaloides*
Fucus vesiculosus	*Cyanidium caldarium*	*Ulva armoricana*

Chitosan and biopolymer:

Chitosan, a deacetylated form of the biopolymer chitin, is produced both naturally and industrially. Its polymers and oligomers, available in various controlled sizes, find applications in the food, cosmetic, medical, and agricultural sectors. In plants, chitosan oligomers exert physiological effects by binding to a wide range of cellular components, such as DNA, plasma membranes, and cell wall constituents. Furthermore, chitosan interacts with specific receptors that trigger the activation of defense genes. Chitosan enhances plant growth by improving nutrient uptake and promoting cell division and elongation, leading to increased root and shoot biomass. It also strengthens plants' resilience to abiotic stresses like drought, salinity, and extreme temperatures by activating stress-responsive pathways and boosting antioxidant activity as shown in table 3. Additionally, chitosan's antimicrobial properties protect plants from pathogens by inducing the production of defense-related enzymes and compounds, thereby enhancing the plant's innate immune response.

Table 3:Chitosan effects on the enzymatic and non-enzymatic antioxidant defense systems (Pichyangkura *et al*., 2015).

Crop	Chitosan type and concentration	Effects
Litchi	Chitosan (90–95% DD and 690–100 mPa s viscosity) at 1%	Increased POX activity
Loquat fruits	Chitosan at 0.75%	Increased ascorbic acid and antioxidant capacity
Peach	Crab-shell chitosan at 5–10 mg/mL	Increased SOD activity

Benefits of biostimulant:

Effects of biostimulants is shown in Table 4:

- Humic substances (HS) derived from various parent materials have been shown to enhance the uptake of total nitrogen (N) and other essential nutrients, including phosphorus (P), manganese (Mn), copper (Cu), zinc (Zn), and iron (Fe), in barley throughout the growing season.
- Application of HS to soils with low organic content has been observed to significantly increase the uptake of phosphorus (P) and iron (Fe) in maize.
- Calcium (Ca) utilization by plants is improved when applied in combination with amino acids (AA). Mixtures of AA and Ca have been effectively used to alleviate Ca deficiency in apples and tomatoes.
- Seaweed extracts (SE) have been reported to induce significant increases in both macronutrient and micronutrient concentrations in plant leaves.
- Plant growth-promoting bacteria (PGPB) enhance plant nutrition through the solubilization of phosphorus (P).

Table 4: Effect of biostimulants.

Species	Concentration	Plant response	References
Broccoli	Seasolw (Dilutions of 1:25, 1:100, 1:200, 1:500 in distilled water (crop drenching with kelp extract at 25 and 2.5 L /ha)	Increased leaf area, stem diameter and biomass	Mattner *et al*. (2013)
Broccoli (*B. oleracea var. cymosa*)	Goemar BM86 2 L ha	Increased yield and content of macro- and micronutrients	Gajc-Wolska *et al*. (2013)
Carrot (*D. carota*)	Aminoplant 1.5 dm^3 /ha	Influenced carrot productivity and chemical composition of the roots	Grabowska *et al*.
Lettuce (*L.*	Radifarm 125 mL/ha	Stimulated root growth	Vernieri *et al.*

sativa)		and induced a more favourable root/shoot ratio	(2002)
Potato (*S. tuberosum cv. Sante*)	'Primo'0.5 mL/ha	Improvement in growth, yield and tuber quality of potato	Haider *et al.* (2012)

Advantages of using the Biostimulant:

Biostimulants offer numerous advantages for modern agriculture by enhancing plant growth, improving nutrient efficiency, and increasing stress resistance. Their use leads to healthier crops, higher yields, and sustainable farming practices. Some of the advantage is explained in fig 7.

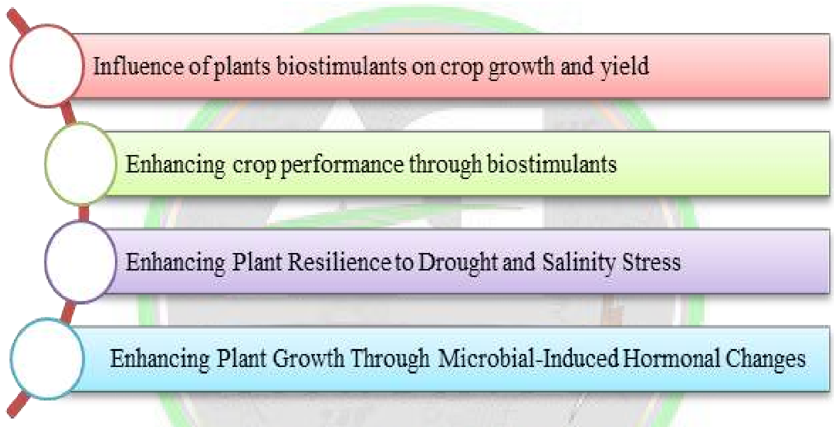

Fig 7: Illustrate advantage of biostimulant.

Influence of plant biostimulants on crop growth and yield:

Plant biostimulants, including seaweed extracts and their derivatives, play a crucial role in crop development. For example, extracts from *Ascophyllum nodosum* have been demonstrated to improve both straw biomass and grain yield in soybean (*Glycine max*).

Enhancing crop performance through biostimulants:

- Optimizes plant metabolic processes, leading to increased yield and improved crop quality.
- Enhances plant resilience and recovery from abiotic stress conditions.
- Facilitates efficient nutrient uptake, movement, and utilization within the plant.
- Improves produce quality, including attributes such as sugar content, colour, and fruit setting.
- Increases water use efficiency in plants.
  - Boosts soil fertility by promoting the growth of beneficial soil microorganisms.

Enhancing Plant Growth Through Microbial-Induced Hormonal Changes:

Microbial inoculants, including Plant Growth-Promoting Rhizobacteria (PGPR), contribute to plant growth by influencing root architecture and overall development through the production or modification of essential plant hormones. These microorganisms can alter the hormonal balance in plants by synthesizing phytohormones such as auxins, cytokinins (CKs), gibberellins (GAs), and ethylene (ET). These hormones play a crucial role in regulating physiological processes, such as root initiation, elongation, and the formation of roothairs.

Enhancing Plant Resilience to Drought and Salinity Stress:

Microbial inoculants that benefit plant growth can also support plants in managing abiotic stress, thereby helping to reduce potential yield losses. For instance, bacteria such as *Rhizobium spp.* and *Azospirillum spp.* have been shown to improve plant tolerance to saline conditions. Similarly, various fungi—including *Neotyphodium spp.*, *Curvularia spp.*, *Colletotrichum spp.*, *Fusarium spp.*, *Alternaria spp.*, and *Trichoderma spp.*—have been found to enhance drought resistance in a range of crops, such a tomato (*Solanum lycopersicum*), pepper (*Capsicum annuum*), ryegrass (*Lolium perenne*), tall fescue (*Festuca arundinacea*), wheat, and barley (*Hordeum vulgare*).

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INTEGRATED MANAGEMENT OF FRUIT DEFORMITY AND ROOT ROT DISEASE IN PAPAYA THROUGH INDIGENOUS PRACTICES IN NEPZ OF INDIA

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Abstract

The present study was carried out at Indian Agricultural Research Institute Regional Station, Pusa, Samastipur (Bihar). Fruit deformity such as bumpy fruit including deformed/discolored seeds occurred on papaya crop in North Eastern Plains Zone (NEPZ) of India causing higher economic losses. This abnormality initially occurs on the epidermis of young fruits, but symptoms become more severe on the mature fruits at ripening stage and check the fruit growth due to boron nutrient deficiency. Fruits become very rough in texture and quality was deteriorated. Latterly, fruits secrete milky substances from these bumpy balls. Due to this anomaly, fruit quality is also disturbed and farmers suffered huge yield loss. Soils of NEPZ are sandy loam alkaline in nature and boron deficient leading to a major constraint for quality papaya production. Basal dose of borax (as disodium octaborate tetrahydrate) @ 5.0 g/plant was found most effective in reducing the bumpiness of fruits as compared to control treatment. Systematic field surveys were conducted in the farmer's field and to observe the severity of this disorder. Despite the fruit deformity, recently, root rot disease also regarded as major serious problem in this region and cause unpredictable incidences in field ranging from 10 to 100% especially in rainy season under NEPZ. Classical symptoms in young papaya plant are yellow and collapse of leaves resulting in a soft, wet rot of the tap root which often extends into the trunk. In a fully fruit bearing trees, the tap root and lateral roots become severely decayed causing plants to topple down after fungal infection and plant die suddenly within 2-3 days. Papaya cultivar 'Pune Selection-3' was found most sensitive for the disorder and root rot disease

as compared to 'Pusa Dwarf'. Integrated practices including cultural control, agronomical practices such as crop rotation, soil amendments with FYM, proper spacing, balanced fertilization, mounding with organic mulch along with fungicides and bio-agents resulted significantly less disease incidence and severity of root rot and bumpiness along with higher yield potential of papaya crop in NEPZ of India.

Introduction

All horticultural fruit crops have been valued as a part of nutritious and tasty diet in daily routine. The fruit flavours are also most preferred throughout the world. Fruits are very good in taste and truly more valuable for human health. In general, it is well-known that all horticultural plant products are useful for traditional medicaments and a rich source of vitamins, organic acids, sugars, phenolics, minerals and dietary fibre that are essential for normal growth and development (Saran and Choudhary, 2013; Saran *et al*., 2015a, b).

Papaya (*Carica papaya* L.) is one of the popular and economically most important fruit crop cultivated throughout the tropical and subtropical regions of the world. It has gained more importance owing to its high palatability, early fruiting, higher productivity per unit area and multifarious uses. The fruits are consumed world-wide as fresh, vegetable or used as processed products.

The fruit disorder, root rot disease incidence, fruit yield and economic losses due to physiological disorders and diseases were observed through the survey of the farmer's field at IARI Regional station, Pusa, Bihar (India). Papaya cultivar 'Pune Selection-3' was found most sensitive for fruit disorder (Figure 1), root rot disease severity and more economic loss, while Pusa Dwarf was tolerant for this disorder and disease severity. Red lady was the more sensitive to leaf curl and PRSV (Table 1; Fig. 3A and 3B). Similarly, Saran *et al.* (2014) reported that the higher susceptibility of Pune Selection-3 to fruit deformity and economic losses than Pusa Dwarf. Due to this abnormality fruit quality is also disturb and farmers suffered huge yield loss (Gupta and Choudhary, 2015).

Basal boron application was applied in papaya crop at the beginning of just before the flowering stage. Basal dose of borax (as disodium octaborate tetrahydrate) @ 5.0 g/plant was found most effective in reducing the bumpiness of fruits as compared to control treatment. Soil application with high amount of borax @ 10g/plant and 15 g /plant also showed effectiveness for disorder management along with toxicity. Toxic symptoms as burning of leaf tips (@10g/plant) and leaf tips along with margin (@15g/plant) were observed in high quantity of borax dosages. Borax @ 5g/plant showed no toxic symptoms on leaves as well as fruits (Gupta and Choudhary, 2015).

Table 1. Physiological disorder and diseases in papaya orchard

Papaya germplasm	Pusa dwarf	Pune selection-3	Red lady
Disorder			
Bumpy fruits	Less	Highest	Medium
Bumpy seeds	Less	Highest	Less
White seeds	Less	Highest	None
Disease			
PRSV	Less	None	Highest
Leaf curl	Less	None	Highest
Root rot	Less	Highest	Medium
Response			
Fruit deformity	Tolerant	Sensitive	Sensitive
Root rot disease	Tolerant	Sensitive	Sensitive
PRSV	Sensitive	Resistant	Highly sensitive

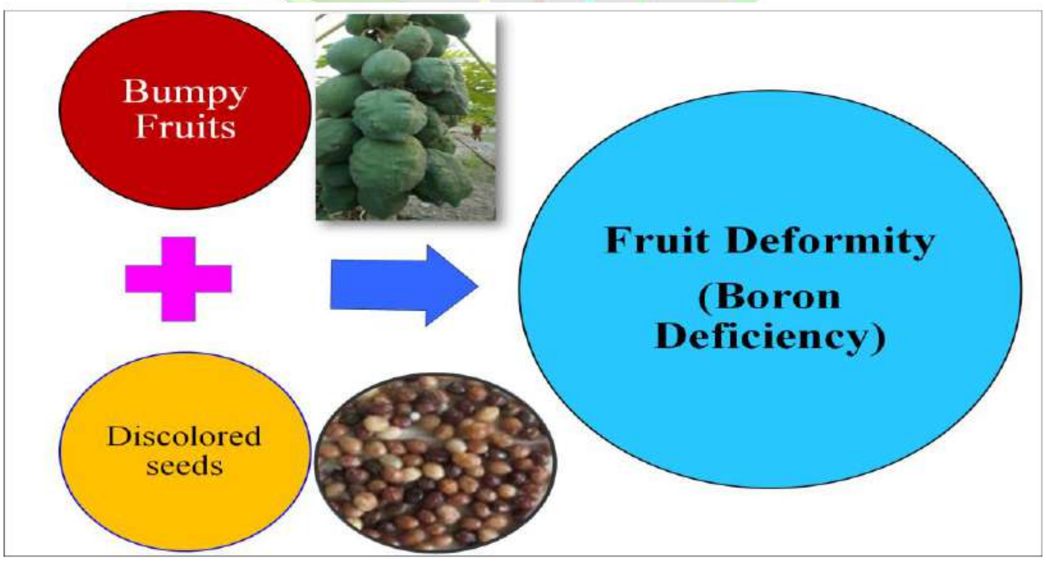

Figure 1: Fruit deformity in papaya showing bumpiness on fruits, discolration of seeds due to boron deficiency.

The effect of different borax doses in papaya plants and toxicity symptoms of boron on leaf margins was observed critically (Saran *et al*., 2015 b). Root rot symptoms in young trees include yellowing and collapse of leaves resulting from a soft, wet rot of the tap root which often extends into the trunk and plant die suddenly in 2-3 days (Figure 2, 3C and 3D). This root rot disease spread vigorously over the orchard and affect all papaya plants rapidly (Figure. 2).

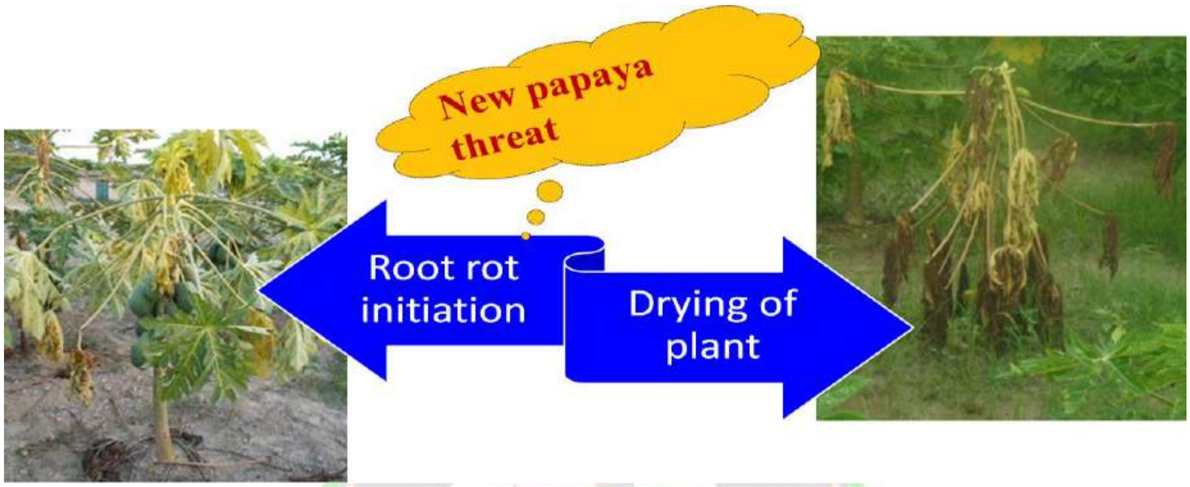

Figure 2: New papaya threat: Root rot disease in papya.

In our survey, mixture of carbendazim + mancozeb (@ 2.5 g/l water) showed good recovery as compared to propiconazole in most of the cases. Despite the fungicides, basic cultural practices like crop rotation, soil amendments with farm yard manure and plantation on raised bed were most effective for the root rot management as compared to flat planting of papaya at farmer's field. Integration of soil mounding with raised bed plus drenching of carbendazim + mancozeb (@ 2.5 g/l water) showed promising to control this serious problem in this region (Gupta and Choudhary, 2015).

In some areas, the high disease pressure situations which often arise during prolonged wet weather conditions, the use of fungicidal chemicals is last resort to the successful management of root rot disease of papaya. Vawdrey *et al*. (2004) showed that foliar sprays of phosphonate (10 g/l) applied fortnightly intervals reduced the incidence of root rot by 47% and metalaxyl applied at transplanting combined with fortnightly foliar sprays of phosphonate also provided a satisfactory level of control of root rot in papaya grown on flat beds.

Fungi are predominantly associated with papaya diseases and their effect may be so devastating that an entire orchard may be affected. Koffi *et al*. (2010) reported significant losses in papaya orchards due to *Pythium aphanidermatum*. This fungus which was the primary pathogen predisposed the plants to secondary infections with *Fusarium* and *Rhizoctonia* species (Oniha and *Egwari*, 2015). Similarily, in present investigation initial isolations resulted the *Fusarium* species and being working to identify the correct information.

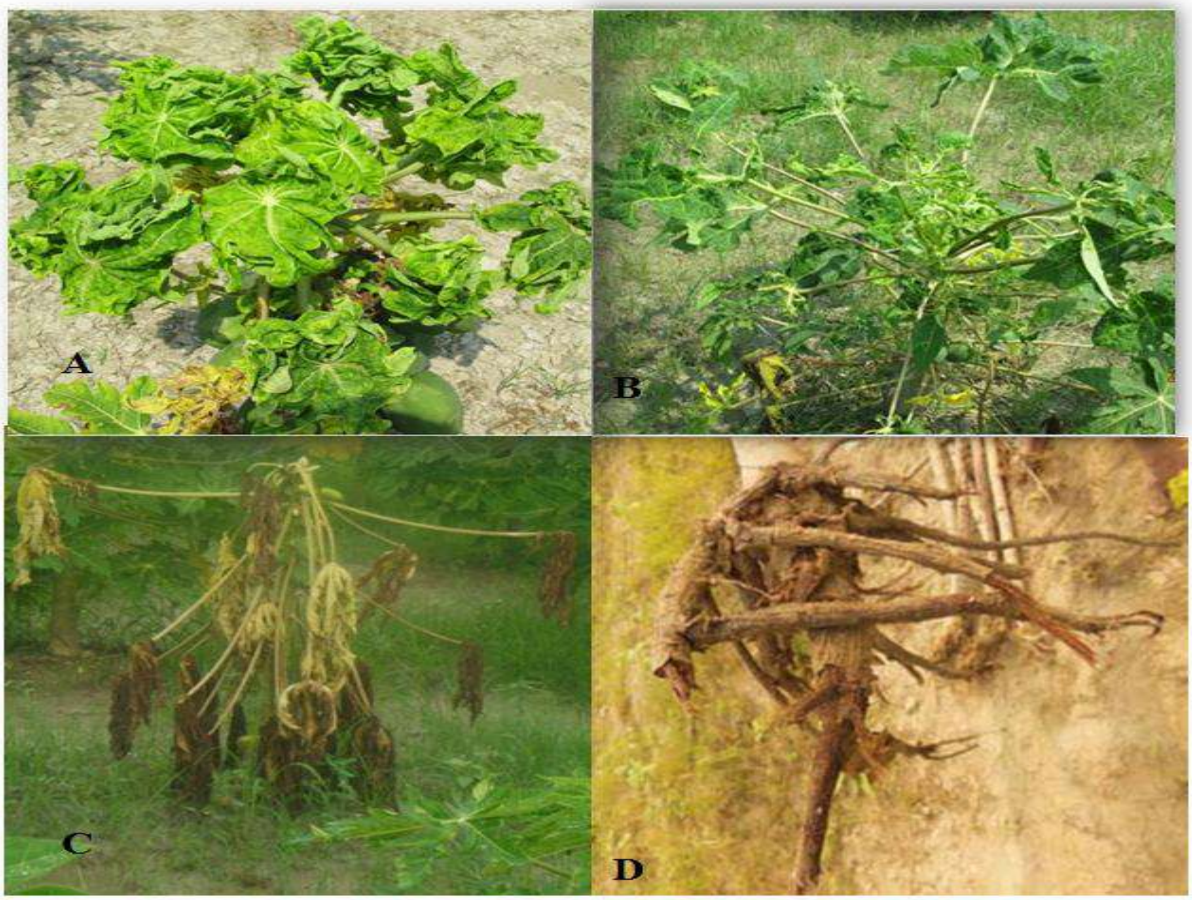

Figure 3: [A] Leaf curl, [B] PRSV, [C] Initiation of root rot disease and [D] Infected root due to root rot in papaya.

Conclusion

In conclusion, planting of papaya on raised bed with basal application of borax @ 5.0 g/plant along with soil mounding of organic mulch plus drenching of carbendazim + mancozeb (@ 2.5 g/l water) resulted significant management of root rot disease and bumpiness of papaya crop in this region. The furthermore experiments have to be conducted for management of this new serious disease in future so that farmers can protect their papaya orchard and also economic yield losses.

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CHITOSAN: A MULTIFUNCTIONAL BIOPOLYMER FOR ENHANCING SEED GERMINATION, PLANT GROWTH, AND STRESS RESISTANCE IN AGRICULTURE"

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Introduction

Chitin, a homo polymer comprising b-(1-4)-linked N-acetyl-D-glucosamine residues, is one of the most abundant, easily obtainable and renewable natural polymers, second only to cellulose. Chitin derivative, chitosan is a poly (1, 4)-2-amino-2-deoxy-b-D glucose. It is a copolymer of 2-glucosamine and N-acetyl-2-glucosamine, derived from chitin, by deacetylation reaction. The D-glucosamine content in chitosan is indicated by the degree of deacetylation (DDA) (Hejazi and Amiji., 2003). Chitosan is a polymer of high molecular weight, similar to cellulose. The only difference between chitosan and cellulose is the amine (–NH2) group in the position C-2 of chitosan instead of the hydroxyl (–OH) group found in cellulose. However, unlike plant fiber, chitosan possesses positive ionic charges, which gives it the ability to chemically bind with negatively charged lipids, metal ions, proteins, and macromolecules (Li *et al.* 1992).

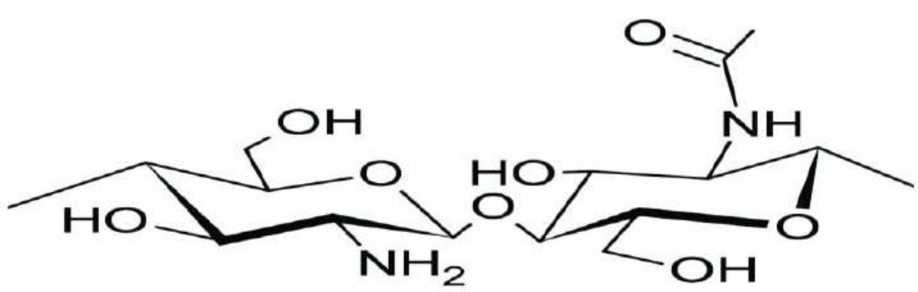

Figure. 1: Structure of chitosan

Sources of chitosan

Chitin occurs in a wide variety of species, from ciliates, amoebae, chrysophytes, some algae, yeasts and the lower animals like crustaceans, worms, insects and mollusks. Vertebrates, plants and prokaryotes do not have chitosan (Sandford., 2004). Fungi are abundant sources of chitosan and it exists naturally in fungi like zygomycetes and mucorales such as Absidiacoerulae (Muzzarelli *et al.*, 1994), Gongronella butleri, Mucorrouxii (Chatterjee *et al*., 2005), Aspergillus niger (Nadarajah *et al.*, 2006).

Importance of Chitosan

Chitosan (CHT) belongs to the group of multifunctional polymers. It is used to design carriers and materials adapted to some specific conditions, as well as the specificity of the application site, which deliver active substances directly to diseased changed tissues. CHT has multiple advantages over other biopolymers (cellulose, starch, galactomannans, etc.): it is safe, inexpensive and its chemical structure easily allows the introduction of specific molecules to design polymers for selected applications. These characteristics confer to CHT a role of great importance for a wide range of potential users ranging from medical and biotechnological industries to agricultural applications.

METHOD OF PREPARATION OF CHITOSAN FROM CHITIN

Chitosan is prepared by 2 methods are mentioned in Figure 2 and 3

Deacetylation of chitin: Most common method of chitosan preparation

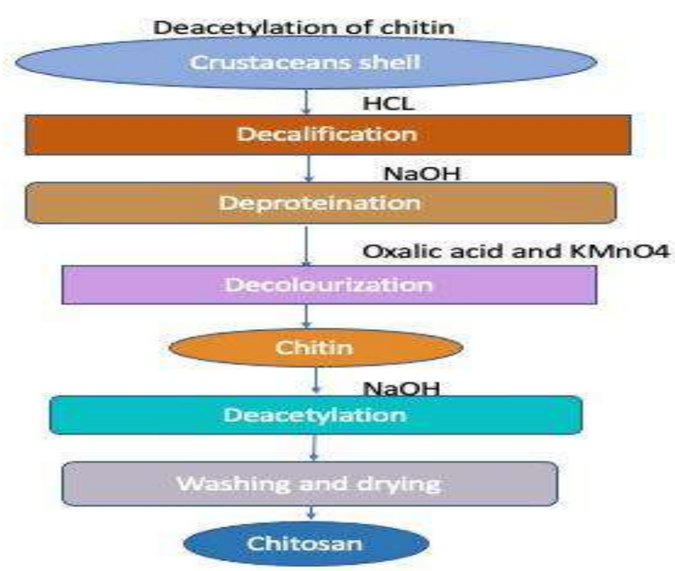

Fig: 1 Deacetylation of chitin

Fermentation technology: Extraction of chitosan from the fungus

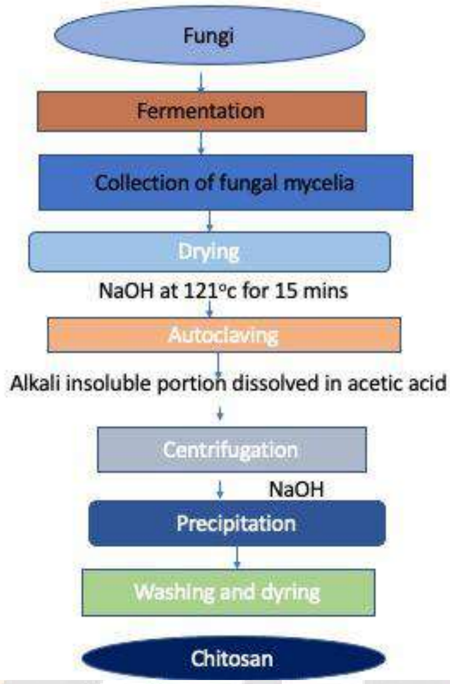

Fig: 3 Fermentation method

Role of chitosan in plant defense mechanisms

Chitosan can induce chitinase and chitosanase, which are members of a group of plant pathogenesis related (PR) proteins. These PR proteins can degrade the cell walls of some phyto pathogens and consequently may play a role in host plant defense systems (Dixon *et al.*, 1994). Moreover, chitosan can also induce plant immune systems (systemic acquired resistance (SAR)), which is long lasting and often confers broad-based resistance against different pathogens. SAR can develop in uninfected parts of the plant, as a result the entire plant becomes more resistant to a secondary infection. Chitosan elicit defense genes in several species such as rice (Rakwal *et al.*, 2002). Chitosan induces the expression of various genes involved in plant defence responses such as genes encoding PAL and protease inhibitors (Vander *et al*.,1998). Chitosan may involve jasmonic acid (JA) pathways, since transcription activation of genes encoding PAL and protease inhibitors are induced by both JA and chitosan (Farmer and Ryan.,1992). Chitosan probably could alleviate the membrane lipid peroxidization and decrease phytotoxicities in plant cells,which can reduce plant cell stress caused by high chemical oxygen demand (COD) in polluted water (Xu *et al.*, 2007). Therefore, the antifungal action of chitosan seems to comprise more than one mode of action by which chitosan affects fungal cell wall biosynthesis and/or alteration of the ability of pathogens to infect and or its ability to increase plant resistance.

Chitosan effect on seed germination

Chitosan offers exciting possibilities for enhancing seed germination and promoting plant growth in agriculture as it's biodegradability, non-toxicity, and ability to improve nutrient uptake and stimulate plant defense mechanisms make it an attractive alternative to synthetic chemicals.

Seed coating/ priming

Chitosan can be used as a seed coating material for cereals, nuts, fruits and vegetables. It alters permeability of the seed plasma membrane, increasing the concentrations of sugars and proline, and enhances peroxidise (POD), catalase (CAT), phenylalanine ammonia-lyase (PAL) and tyrosine ammonialyase (TAL) activities . Germination rates of seeds increases significantly and seedlings germinate quicker, better, and are vigorous. Seed soaked with chitosan had increased the energy of germination, germination percentage, lipase activity, and gibberellic acid (GA_3) and indole acetic acid (IAA) levels in peanut. Seed priming in maize increases chilling tolerance. Priming with chitosan reduced the relative permeability of the plasma membranes of the maize under low temperature leads to less damage from low temperature stress (Guan *et al.*, 2009). The decline of malondialdehyde (MDA) which is an indicator of lipid peroxidation is also induced by chitosan coating due to increase in antioxidant activity.

Chitosan and its effect on seed growth

The application of CHT as in vitro, in vivo, soil application, pot application and biofertilization to promote plant growth. CHT facilitates plant growth by increasing the uptake and availability of water and important nutrients by adjusting osmotic pressure in the cells (Guan *et al.*, 2009). Signaling mechanisms of CHT and its derivatives control plant growth and development processes. Signaling induced by chitosan for ROS is mentioned in Figure 4. CHT helped to activate the hydrolytic enzymes needed to degrade and mobilize reserve food materials including starch and protein (Hameed *et al.*,2013). CHT can promote the division of root cells by activating plant hormones including auxin and cytokinin that further lead to increased nutrient intake (John et *al.*,1997, Dzung *et al.*, 2011). Other potential contributions are higher seed germination, enhanced seedling growth and development, and activation of antioxidant enzymes to prevent the potential damage by the reactive oxygen species (ROS) at the time of seed germination [Hameed *et al.*,2013). Plant-growth-enhancing activities of CHT can be directly linked to impacts on plant physiological mechanisms, including nutrient absorption, cell division, cell elongation, enzymatic activation and synthesis of protein. Seed priming with CHT Nanoparticles (NPs) stimulated seed germination percentage and the vigor index of maize, tomato, and chickpea, leading to the early establishment of healthy seedlings. CHT has an excellent property of forming a semi-permeable film on the seed surface that can retain the moisture of the seed and absorb additional moisture from the soil, thereby promoting seed germination. Treatment of maize seed with Cu-chitosan NPs controlled the synthesis of hydrolytic enzymes like protease and α-amylase, and strengthened their activities. Increased activity of protease and α-amylase led to the rapid mobilization and degradation of preserved food, which resulted in increased germination and SVI of maize (Saharan *et al.,* 2016). CHT NPs also significantly enhanced the biophysical properties, such as the nutrient intake and net rate of photosynthesis, which contributed to coffee seedling growth promotion. Positively charged nano-sized CHT can easily penetrate into plant cells or adhere to plant surfaces and enhance seed germination and biophysical properties. CHT also increased crop yield substantially by improving the index of photosynthesis by enhancing stomatal function and chlorophyll content. The polycationic CHT raises stomatal cells' osmotic pressure, resulting in increased stomatal opening and CO2 integration.

Fig 4: Signaling induced by chitosan

Conclusion

Chitosan, derived from chitin, plays a pivotal role in enhancing seed germination and plant growth through its unique properties. It is biodegradable, non-toxic, and promotes nutrient uptake, seed vigor, and plant defense mechanisms. Its positive ionic charges enable it to interact with various molecules, improving seed permeability and stimulating antioxidant activities, which lead to better stress tolerance and overall plant health. Chitosan seed treatments, including coatings and priming, enhance germination rates, promote faster seedling growth, and improve crop resilience to environmental stress. Furthermore, chitosan nanoparticles (CHT NPs) offer additional benefits by improving enzymatic activity, nutrient absorption, and photosynthesis, leading to increased crop yields. Thus, chitosan represents an eco-friendly, sustainable alternative for boosting agricultural productivity and plant resilience.

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PARASITIC DISEASES IN AQUACULTURE

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Introduction

Aquaculture is the fastest-growing sector globally, providing over 50% of the world's seafood consumption and employing millions worldwide (Debnath et al., 2023). Aquaculture presents immense potential in many countries to enhance food security and boost export revenues. While the intensification of aquaculture practices has successfully increased production, it has also led to various diseases caused by viruses, bacteria, and parasites. This is largely due to the failure to balance host, pathogen, and environment, which is crucial for the sector's sustainable growth. Aquaculture systems create environments conducive to the growth and reproduction of cultured species, but these conditions can also lead to the growth of potential pathogens. Like other cultured organisms, fish are susceptible to a range of pathogens. The intensification of farming methods often exacerbates these risks, leading to more frequent disease outbreaks. Fish are prone to diseases caused by pathogens, and while parasitism is widespread in marine ecosystems, fish in cultured environments are similarly vulnerable to parasitic infections. Diseases have significantly constrained aquaculture production worldwide, hindering economic and social development in numerous countries (Iqbal et al., 2023). This situation arises from various factors, including the intensification and diversification of aquaculture practices. The translocation of broodstock, post-larvae, fry, and fingerlings has contributed to the spread of diseases. Globalising live fish trade and related products has also increased the risk of disease transmission. Further complicating the issue, enhancing coastal ecosystems by stocking hatchery-raised aquatic animals has led to unforeseen negative interactions between cultured and wild fish populations. Many regions also suffer from inadequate or ineffective biosecurity measures and a slow response to emerging diseases. Most critically, global climate change and human-mediated movements of aquaculture commodities exacerbate these challenges (Opiyo et al., 2020). Controlling diseases within aquaculture systems is a complex undertaking that relies on a multifaceted approach, encompassing pathogen detection, accurate disease diagnosis, and effective treatment strategies. Addressing these challenges is essential for the sustainable growth of the aquaculture industry (Behringer et al., 2020).

Parasitic Diseases in Aquaculture

Parasitic diseases are caused by parasites, organisms that feed on or harm another organism known as the host. Fish infected with parasites may suffer direct injury, experience slower growth rates, and become more vulnerable to secondary illnesses. Parasites are internal (endoparasites) or external (ectoparasites). Endoparasites reside inside the host's body, while ectoparasites live on the host's outer surfaces. The impact of parasitic infections can lead to morbidity and mortality in fish, reduced growth rates, and decreased reproductive success. Transmission of parasites can occur through direct contact, environmental exposure, or via intermediate hosts, complicating the management of these diseases. Factors such as overcrowding, poor water quality, and inadequate biosecurity measures in aquaculture systems can exacerbate the spread of parasites (Iqbal et al., 2023).

Types of Parasites in Aquaculture

Aquatic organisms, including protozoans and farmed fish, are susceptible to various types of parasites:

Protozoans: Single-celled organisms that can seriously harm fish health, such as Trichodina, *Ichthyophthirius multifiliis* (Ich), and *Cryptocaryon irritans*.

Monogeneans: Mostly ectoparasites, these flatworms attach to the fins, skin, or gills of fish. Examples include Gyrodactylus spp. and Dactylogyrus spp. *Bothriocephalus acheilognathi* is an intestinal parasite that can infect various freshwater animals, resulting in intestinal obstruction and malnourishment.

Nematodes (Roundworms): Common intestinal parasites with potential tissue infection. Freshwater fish may host species like Camallanus, which can cause weight loss and illness.

Copepods (Crustaceans): Notable parasites in aquaculture include Lernaea (anchor worms) and Caligus (sea lice). These parasites can cause tissue damage and lead to bacterial infections, potentially resulting in death.

Diseases Caused by Parasites

White Spot Disease: Caused by the ciliated protozoan *Ichthyophthirius multifiliis*, this disease penetrates the epidermis of freshwater fishes. Rapid multiplication of epidermal cells forms white spots on the skin and fins. The parasite's movement can cause discomfort, and in severe cases, the fish may develop nodules on their gills and body. Effective treatment during the encysted stage is challenging, but parasites can be eliminated during their free-swimming phase. Solutions include a 3% salt solution, a 1:4000 formalin solution, or a 1:500,000 methylene blue solution.

Gyrodactylus: A common ectoparasite found on carp and trout's bodies, fins, and gills. It has a disc-shaped attachment organ called a haptor. Infected fish may appear pale, and the affected areas can be covered in bluish slime. Fins may gradually tear. Effective treatments include formaldehyde, saltwater, and chlorine or iodine compounds.

Dactylogyrus: This monogenean parasite can cause severe gill infections.

Infected fish may swim near the surface, gasping for air due to gill damage, leading to red, swollen gills and visible mucus. Prolonged infections may result in weight loss due to decreased feeding. Antiparasitic medications such as metronidazole, levamisole, and praziquantel can treat Dactylogyrus infections.

Fish Louse (Argulus): A well-known ectoparasite affecting many fish species, including carp. Infected fish may exhibit unusual behaviours, such as rubbing against objects to relieve discomfort. Inflammation, redness, and ulcers may develop at the attachment sites. Organophosphates like Trichlorfon or Dimilin can effectively combat Argulus by inhibiting parasite reproduction. Additional treatments include saltwater and potassium permanganate.

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ENDOPHYTES: ROLE IN SEED QUALITY

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Abstract

Endophytes, microorganisms that reside within plant tissues, including bacteria and fungi, play a pivotal role in enhancing seed quality without causing harm to their host plants. These symbiotic or mutualistic microorganisms provide numerous benefits such as growth promotion, stress tolerance, and disease resistance. They improve plant resilience to various stresses such as drought, salinity, and heavy metal toxicity, and help in nutrient uptake through processes like nitrogen fixation and phosphate solubilization. In agriculture, the application of endophytes, especially through seed priming or inoculation, boosts seed germination rates, early seedling vigor, and pathogen resistance. Moreover, endophytes enhance seedling root and shoot growth, improve nutrient bioavailability, and increase seed longevity and storage viability by mitigating oxidative damage. They also contribute to biofortification by accumulating essential micronutrients like iron and zinc, thus improving the nutritional quality of seeds. The diverse benefits of endophytes not only increase crop yields but also improve the overall quality of seeds, making them a promising tool in sustainable agricultural practices.

Key words: Endophytes, Germination, Longevity, Priming and Seedling vigour.

Introduction

Endophytes are microorganisms usually bacteria or fungi that live inside plant tissues without causing any apparent harm to the host plant. They form a symbiotic or mutualistic relationship with the plant, often provides benefits such as enhanced growth, stress tolerance, or disease resistance. Endophytes can be found in various parts of the plant, including roots, stems, leaves, and seeds.

Types of Endophytes are:

1. **Fungal Endophytes**: *Ascomycota* and *Basidiomycota*.
2. **Bacterial Endophytes**: *Bacillus*, *Pseudomonas*, and *Azospirillum* these often reside in root systems and can be nitrogen-fixing, especially in legumes (Table 1).

Table 1: Examples of Endophytes Used in Enhancing Seed Quality

S.No	Endophyte Species	Host Crop	Effect on Seed Quality
1.	*Pseudomonas fluorescens*	Rice	Enhances seed germination, root growth, and drought tolerance.
2.	*Bacillus subtilis*	Wheat	Increases seedling vigor, disease resistance, and phosphorus availability.
3.	*Bradyrhizobium japonicum*	Soybean	Promotes nitrogen fixation and enhances seed protein content.
4.	*Azospirillum brasilense*	Tomato	Enhances seed germination and salinity tolerance.
5.	*Epichloë festucae var. lolii*	Barley	Improves drought resistance and seedling vigor.
6.	*Trichoderma harzianum*	Alfalfa	Enhances seed germination and protects against fungal pathogens.

Benefits of Endophytes are:

1. **Growth Promotion**: Endophytes can promote plant growth by producing phytohormones such as auxins, gibberellins, and cytokinins and helps in nitrogen fixation, enhancing the nutrient availability for the plant.
2. **Stress Tolerance**: Endophytes improve plant resilience against various stresses, including drought, salinity, and heavy metal toxicity by modulating root architecture, and improving water and nutrient uptake.
3. **Disease Resistance**: Endophytes can act as biological control agents by producing antimicrobial compounds or inducing systemic resistance in the plant, that helps to protect against pathogens like fungi, bacteria, and viruses.

4. **Abiotic Stress Tolerance**: Endophytes produce enzymes and metabolites that help plants mitigate the effects of abiotic stresses such as high salt levels, extreme temperatures, and heavy metal contamination. Endophytes may help enhance water absorption through symbiotic interactions, leading to better drought tolerance.

Application of Endophytes in Agriculture

Endophytic bacteria and fungi can be inoculated into crops to enhance growth and stress tolerance. This is especially useful in sustainable farming practices, reducing reliance on chemical inputs. For seeds they can be coated or primed with beneficial endophytes to improve germination rates, early seedling vigor, and resistance to diseases.

Role of endophytes in seed quality:

1. Enhanced Germination Rate and Seedling Vigor: Endophytes produce phytohormones like auxins, gibberellins, and cytokinins that enhance seed germination by promoting cell elongation and division. They can also reduce germination time, leading to faster emergence of seedlings. Endophytes help improve seedling vigor by enhancing root and shoot growth. This leads to more robust seedlings, capable of better nutrient and water uptake, which is critical for establishing strong crops (Fig 1).

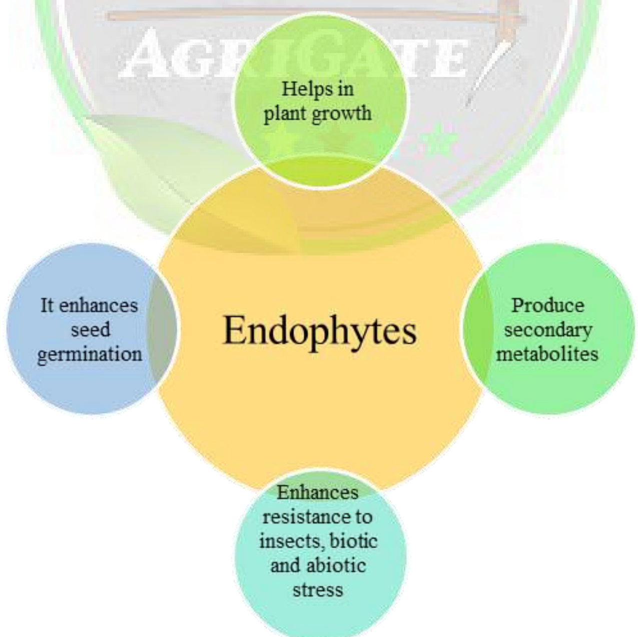

Figure 1: Importance of endophytes

2. Improved Nutrient Uptake: They enhances the nutrient availability to seeds by fixing nitrogen or solubilizing phosphates and other essential nutrients. This ensures that the seeds have adequate nutrient reserves, which positively impacts seed size, weight, and overall quality. The improved nutrient status also enhances seed biochemical composition, including higher protein and nutrient content, which is particularly important for crops intended for food production.

3. Disease Resistance and Pathogen Protection: Endophytes act as natural biocontrol agents against seed-borne and soil-borne pathogens. They produce antimicrobial compounds such as antibiotics, volatile organic compounds (VOCs), and lytic enzymes that inhibit the growth of harmful microbes. Endophytes can trigger induced systemic resistance (ISR) in seeds, making them more resistant to pathogens, they contributes to seed health, reducing disease incidence during germination and early growth stages.

4. Stress Tolerance: Endophytes improve seed tolerance to drought by enhancing water uptake efficiency and producing compounds like osmolytes that help retain moisture. This allows seeds to germinate and establish seedlings under water-limited conditions. Seeds treated with endophytes have been shown to exhibit better germination and growth in saline soils and extreme temperatures. The endophytes help mitigate the toxic effects of salts or provide protective compounds that shield seeds from temperature extremes. In contaminated soils, endophytes can help seeds tolerate heavy metals by sequestering the metals or transforming them into less harmful forms. This enhances seed germination and growth even in polluted environments.

5. Improvement in Seed Longevity and Storage: Seeds treated with endophytes tend to have longer shelf life and better viability during storage. The microbial association can prevent seed deterioration caused by oxidative damage or pathogen attack during storage. Some endophytes can inhibit the growth of mycotoxin-producing fungi, such as *Fusarium* and *Aspergillus* species, during seed storage. This reduces the risk of mycotoxin contamination, which is important for maintaining seed quality in storage and enhancing food safety.

6. Seed Biofortification: Endophytes can help in biofortification of seeds by increasing the accumulation of essential micronutrients like iron, zinc, and selenium. This not only enhances seed quality but also contributes to the nutritional value of crops grown from these seeds.

7. Priming Effects: Seed priming with endophytes (coating or soaking seeds in endophyte solutions before planting) is a common technique that significantly enhances seed quality. It boosts germination rates, early seedling vigor, and resilience to environmental stresses. Endophyte-primed seeds often show enhanced metabolic activity, including higher enzyme activity (e.g., amylases, proteases), which accelerates seed germination and boosts early growth performance (Table 2).

Table 2: Endophytes application methods and its benefits

Crop	Endophyte Type	Endophyte Species	Benefits to Seed/Crop Quality	Application Method	References
Rice (*Oryza sativa)*	Bacterial Endophyte	*Pseudomonas fluorescens*	Enhances seed germination, improves root growth, increases drought and salinity tolerance.	Seed inoculation, soil application	Verma *et al.*, 2018
Maize (*Zea mays*)	Fungal Endophyte	*Piriformospora indica*	Improves nutrient uptake, promotes seedling vigor, increases resistance to soil pathogens, enhances drought tolerance.	Seed priming, root inoculation	Yadav *et al.*, 2010
Wheat (*Triticum aestivum*)	Bacterial Endophyte	*Bacillus subtilis*	Increases seedling vigor, improves phosphorus availability, promotes resistance to fungal pathogens, enhances yield.	Seed treatment, biofertilizer coating	Liu *et al.*, 2017
Soybean (*Glycine max*)	Bacterial Endophyte	*Bradyrhizobium japonicum*	Promotes nitrogen fixation, enhances seed protein content, improves drought and stress resistance.	Seed inoculation	Hungria *et al.*, 2005
Barley (*Hordeum vulgare*)	Fungal Endophyte	*Epichloë festucae var. lolii*	Increases seedling vigor, provides drought resistance, enhances resistance	Seed treatment, plant inoculation	Johnson *et al.*, 2013

Crop	Endophyte Type	Endophyte Species	Benefits to Seed/Crop Quality	Application Method	References
			to herbivores and fungal pathogens.		
Tomato (*Solanum lycopersicum*)	Bacterial Endophyte	*Azospirillum brasilense*	Improves seed germination, enhances nutrient uptake, increases resistance to salinity, promotes overall plant growth.	Seed treatment, biofertilizer coating	Bashan & de-Bashan, 2010
Cotton (*Gossypium hirsutum*)	Bacterial Endophyte	*Bacillus amyloliquefaciens*	Promotes seed germination, enhances resistance to fungal pathogens, improves drought tolerance, boosts yield.	Seed coating, root inoculation	Han et al., 2006
Alfalfa (*Medicago sativa)*	Fungal Endophyte	*Trichoderma harzianum*	Increases seed germination, enhances nitrogen fixation, improves resistance to fungal pathogens, promotes overall plant health.	Seed treatment, soil amendment	Harman *et al.*, 2004
Chickpea (*Cicer arietinum*)	Bacterial Endophyte	*Rhizobium leguminosarum*	Enhances nitrogen fixation, increases seed yield, improves drought tolerance, promotes early seedling vigor.	Seed inoculation	Shamseldin & Werner, 2005
Ryegrass (*Lolium*	Fungal Endophyte	*Epichloë typhina*	Enhances drought tolerance, protects	Seed priming,	Cheplick & Faeth,

Crop	Endophyte Type	Endophyte Species	Benefits to Seed/Crop Quality	Application Method	References
***perenne*)**			against herbivores, improves disease resistance, increases overall seed quality.	foliar inoculation	2009

8. Increased Seed Yield and Quality: Seeds produced from plants harbouring endophytes generally have improved overall quality, such as higher weight, size, and nutritional content. Endophytes can increase crop yields by enhancing seed production and boosting the resilience of the plants that produce them.

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CLEAN MILK PRODUCTION – A PRACTICAL APPROACH

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Introduction

Milk is the main product obtained from the dairy enterprise and mostly utilized as food for human consumption. Milk composed of approximately water 87.2%, fats 3.7%, protein 3.5%, lactose 4.9%, ash 0.7% and has a pH of 6.8. Milk is universally recognized as a complete diet so, it is important to produce a high quality milk to the consumers. The key factor for quality dairy products is to avoid contamination of the raw milk and milk products. Failure to maintain adequate sanitation practices has been contribute to the contamination of milk with undesirable or pathogenic micro-organism or chemical or any physical hazards. If these microorganism enters into milk it can multiply and causes changes to its quality and it can also cause harm to human consumption and lead to diseases. Milk should be handled with a proper care and management. Therefore, the aim for clean milk production is achieved by practical application of science based system called Hazard Analysis Critical Control Point (HACCP).

SOURCE OF CONTAMINATION OF MILK AND CONTROL MEASURES

Source of contamination	Control measures
Interior of the udder	➢ Check for mastitis ➢ Discard foremilk
Exterior of the cow, particularly udder and flanks	➢ Wash and wipe udder ➢ Clip the udder and flanks ➢ Dry milking

The milker	➢ Clean habits ➢ Dry milking
Utensils	➢ Clean, sanitize and dry before use
Flies and other vermin	➢ Eliminate breeding places ➢ Fly control with fly sprays, fly tapes. etc
Environment	➢ Maintaining shed clean by disinfecting regularly ➢ Avoid dusty feed stuffs prior commencement of milking.

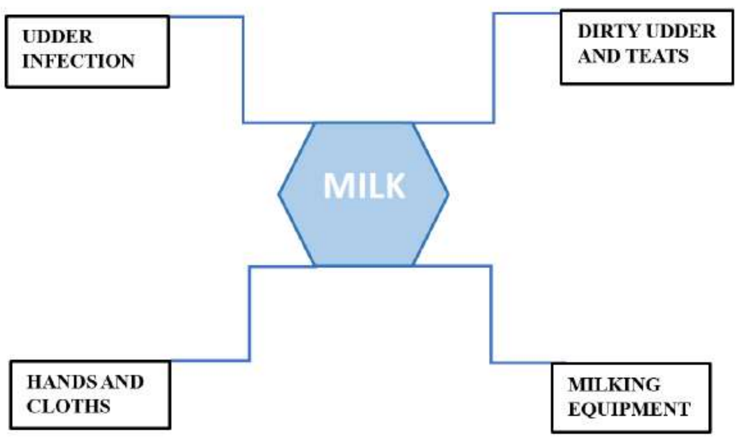

Figure represent the possible source of contamination of milk

MEASURES TO PRODUCE CLEAN MILK:

- Healthy cows and diagnosis of mastitis
- Housing and feeding management
- Clean milkers and milking method
- Milking utensils
- Storage of milk
- Transportation of milk

HEALTHY COWS AND DIAGNOSIS OF MASTITIS:

Milking should be done from animal free from disease like mastitis, brucellosis, FMD, tuberculosis etc. Rapid diagnosis of animal for mastitis using California Mastitis Test (CMT) by mixing milk and CMT reagent which is mainly based on somatic cell count in milk. Lactose and lactate dehydrogenase content are used for indication of udder health status and mastitis. Therefore, testing of milk for communicable disease should be done regularly. Animal should be cleaned every day and regular cleaning of udder and teat before and after milking should be done, lack of cleaning leads to infection or contamination of milk.

Tabel 1: Interpretation of CMT score

CMT Result	Gel formation and curdling formation	Somatic cell count
Positive	-Present-	200,000 - 400,000 (Sub-clinical mastitis) 400,000 - 1,200,000 (Sub-clinical mastitis) 1,200,000 - over 5,000,000 (Severe mastitis)
Negative	-Absent-	0-200,000 (Healthy Quarter)

HOUSING AND FEEDING MANAGEMENT

- **Freedoms for animals:** Dairy animal should have freedom for drinking water, shelter, feed, free from injury, pain and disease and providing a proper diet which having all vital requirements needed for it. Sufficient spacing and free from stress and mental suffering. Lack of any of these can also lead to reduction in milk yield.
- A proper drainage system should be constructed so that the urine, faeces and dirt can be drained into it. The shed should be constructed in a sloppy manner so that it can be drained off easily.
- Regular cleaning and disinfecting of shed is recommended and shed should be highly ventilated, lack of ventilation leads to stress in animal which may also affect the health and milk yield as well. Hence, 500 cubic feet of air space should be provided per animal.
- Animal should not be served with leftover or contaminated feed which may affect the health of animal. It should be feed with all essentials that includes carbohydrates, protein, fats and minerals in a diet like bypass protein feed, Mineral mixtures for metabolic functions of the body, brans, oil cakes, grains, urea molasses block licks etc. which can help in milk production, metabolic function and health of animal.

CLEAN MILKERS AND MILKING METHOD:

- Milker should be free from any contagious disease. Scrubbing and washing their hands before milking and finger nails kept trim and clean, to prevent injury to the teat
- Avoid dirty habits of sneezing and coughing during milking.
- Proper milking method should also be practiced by milkers like instead of knuckling a free hand milking method should be done.
- Milker should clean udder and teat before milking, after milking the milk should be stored in dry container free from water and a proper covering should be provided for container to prevent spoilage of milk.

MILKING UTENSILS:

- Milking utensils should have small mouths to avoid external contamination. These should be preferably made up of non-rusting and non-absorbent materials like stainless steel.
- All the utensils should be free from dents, cracks or holes to prevent seepage of milk. Utensils should be scrubbed and cleaned with disinfectant before and after each milking and it should be dried in sunlight before loading of milk.
- And after loading of milk the container should be closed with container with a proper coverage to prevent contamination of milk by dusts, insects etc.

STORAGE, TRANSPORTATION AND CLEANING OF MILK:

- By storing the milk at cool temperature the multiplication of bacteria delayed. Milk should be cooled to the temperature of 4°C in a refrigerator to preserve its keeping quality.
- Some other cooling method like refrigerator, water, ice, a direct expansion surface cooler, an ice bank and chilled water are the most often used cooling aids.
- Transportation of milk in clean container in a minimal time is must. Vigorous movement of the milk during transportation should be avoided as milk fat can soon turn rancid in the presence of oxygen. Therefore a proper care and management should be taken care in transportation of milk.

Conclusion

Milk is an essential requirement for the consumers largely hence, the quality of milk should be maintained because, it is important for both health and financial need. To produce a clean milk one should follow few practices such as filtration of milk, covering of utensils with lid, cleaning of utensils and periodic examination with veterinarian, isolation of cattle from the diseased ones, vaccination of cattle, washing of floor with detergents and teat washing with teat solution should be followed. Therefore, for a proper attainment of clean milk improves economically the producer and also the health of the consumer. Therefore, it is recommended that training and guidance should be given to dairy farmers so they can improve the need for hygienic practice in the farm. Public health officials should inform or create awareness to the workers about the needs and requirements in the milk production so that public can be protected from various zoonotic disease.

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MICROALGAE-BASED MEAT ANALOGUES: NUTRITIONAL POTENTIAL, TECHNOLOGICAL ADVANCEMENTS, AND FUTURE OPPORTUNITIES

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Abstract

Microalgae-based meat analogues have gained significant attention as a promising alternative to conventional meat products. As consumers become more conscious of the environmental impact of traditional meat production, there is growing interest in plant-based and microalgae-derived protein products that mimic the texture, taste, and nutritional properties of meat. This review highlights the potential of microalgae in developing meat analogues, focusing on recent advancements in formulation, processing technologies, and functional applications. The challenges associated with sensory properties, scalability, and consumer acceptance are also discussed.

Keywords: microalgae, meat analogues, protein source, functional properties

Introduction

The growing demand for sustainable protein sources has spurred the development of plant-based and alternative meat products. Meat analogues are designed to replicate the sensory attributes, nutritional profile, and functionality of conventional meat products, while offering more sustainable and ethical options. Microalgae, microscopic photosynthetic organisms, are increasingly being recognized as a viable protein source for meat substitutes due to their high protein content, essential fatty acids, vitamins, minerals, and bioactive compounds.

Microalgae such as Chlorella, Spirulina (Arthrospira), and Dunaliella possess unique qualities that make them ideal for use in meat analogues. They offer nutritional benefits and have lower environmental footprints compared to animal farming. In this review, we explore the use of microalgae as an ingredient in meat analogues, recent advancements in formulation, and the challenges and future directions in the commercialization of these products.

Nutritional Profile of Microalgae for Meat Analogues

Microalgae offer a rich source of nutrients, which make them a promising candidate for meat analogues:

Protein Content: Microalgae, especially Spirulina and Chlorella, contain high levels of protein (up to 70% of dry weight), and are known for having a well-balanced amino acid profile, including all essential amino acids like lysine, leucine, and tryptophan. This makes microalgae-based meat analogues highly nutritious, especially for plant-based diets. Microalgae species, such as, with a well-balanced amino acid profile, comparable to traditional meat sources (Cabarkapa *et al.*, 2022). **Table 1** shows protein contain in microalgae for meat analogue.

Table 1. Protein content in microalgae for meat analogue.

Sl. No.	Microalgae Species	Protein Content (%)
1	Spirulina	50-70%
2	Chlorella	45-60%
3	Dunaliella	30-40%
4	Nannochloropsis	35-40%

Lipids and Fatty Acids: Microalgae are also rich in polyunsaturated fatty acids (PUFAs), including omega-3 and omega-6 fatty acids, which are essential for human health. Docosahexaenoic acid (DHA) and Eicosapentaenoic acid (EPA) are important polyunsaturated fatty acids (PUFAs) that are significantly produced by certain microalgal species. These compounds accumulate through the marine food web and are of particular interest due to their bioactive properties. Consistent intake of EPA and DHA supplements has been shown to reduce inflammation and help prevent cardiovascular disease. Additionally, DHA is essential for maintaining the fluidity of cell membranes, particularly in the brain and retina (Kumar *et al.*, 2019).

***Vitamins and Minerals**:* Microalgae provide a wide range of micronutrients, such as vitamin B12, iron, calcium, and magnesium, that are often lacking in plant-based meat alternatives.

***Bioactive Compounds**:* Microalgae are a rich source of antioxidants, carotenoids, and other bioactive compounds, which offer additional health benefits beyond basic nutrition.

These attributes make microalgae a versatile ingredient for meat analogues, providing not only protein but also valuable nutrients that enhance the overall nutritional profile of the final product.

Recent Advances in Microalgae-Based Meat Analogues

Microalgae as a Protein Source for Meat Analogues

Microalgae-based protein has been successfully incorporated into meat analogues to improve their texture, nutritional content, and sustainability. In recent years, formulations have been optimized to balance protein content with other functional ingredients such as starches, fibres, and binders to mimic the texture of traditional meat products. Studies have shown that microalgae proteins contribute to the desired fibrous texture and juiciness of meat analogues, while also enhancing their nutritional content. For example, Chlorella and Spirulina have been used in meatless burgers, sausages, and chicken-like products with favourable results in terms of texture and appearance.

Processing Technologies

The development of microalgae-based meat analogues has been supported by innovations in food processing technologies. High-moisture extrusion and 3D food printing are among the emerging technologies that have been applied to replicate the texture and structure of meat using microalgae-based ingredients.

- **High-Moisture Extrusion**: This method creates fibrous, meat-like textures by extruding a mixture of proteins under controlled temperature and pressure. Microalgae proteins have shown compatibility with high-moisture extrusion processes, leading to the creation of meat-like textures similar to those achieved with soy or pea protein Low- and high-moisture extrusion are two common methods used to create products with desirable functional properties, though both operate on the same basic principle. Low-moisture extrusion, which involves moisture levels below 40%, is typically used to produce texturized vegetable proteins (TVP) that have low moisture content and a slightly expanded structure. These proteins are often rehydrated and processed into plant-based products like nuggets, chunks, and strips. Conversely, high-moisture extrusion, which operates with moisture levels above 50%, produces softer products with fibrous, meat-like structures that offer enhanced texture and sensory qualities (Singh and sit, 2022; Ozturk and Hamaker, 2023).

- **3D Printing**: 3D food printing technology has opened new possibilities for producing customizable meat analogues with intricate structures and textures. Microalgae-based materials are well-suited for 3D printing due to their gel-forming properties and ability to hold structure during the printing process. 3D printing enables the production of meat analogues that closely resemble the appearance and texture of real meat, while also allowing for the customization of nutritional content and flavor to meet specific consumer preferences. Despite its potential, the technology faces several challenges when applied to meat analogue production. One of the most significant difficulties is developing edible inks with the necessary printability characteristics. These inks must have suitable rheological properties to ensure smooth extrusion through the printer nozzles while maintaining their structure post-printing. It is often challenging to achieve these printing properties using alternative proteins alone, which is why they are typically combined with hydrocolloids to adjust their rheology and make them more compatible with 3D printing applications (Mirzapour-Kouhdasht *et al.*, 2024).

Functional Properties of Microalgae Proteins

Microalgae proteins offer functional properties that enhance the overall quality of meat analogues. These include emulsification, gelation, water-binding capacity, and foaming ability, which are essential for replicating the mouthfeel, juiciness, and texture of meat. Research has shown that microalgae proteins, particularly from Chlorella and Spirulina, exhibit strong emulsifying and gelling properties, making them suitable for creating plant-based burgers, sausages, and other meat substitutes (Ferreira *et al.*, 2021).

Challenges in Microalgae-Based Meat Analogues

While microalgae offer several advantages for meat analogue production, there are challenges that must be addressed for wider commercial adoption:

Sensory Properties

The green colour and earthy taste of microalgae, especially species like Spirulina and Chlorella, can affect the sensory appeal of meat analogues. Consumers are accustomed to the appearance and flavour of traditional meat, and overcoming these sensory differences remains a key challenge. Recent efforts have focused on masking the natural colour and flavour of microalgae by using flavour enhancers and colour-neutral microalgae strains.

Cost and Scalability

The high cost of cultivating microalgae, particularly in controlled environments like photobioreactors, limits the scalability of microalgae-based meat analogues. Efforts to reduce production costs include optimizing cultivation systems, improving strain selection, and utilizing waste streams from other industries (such as food or biofuel production) for nutrient supplementation.

Regulatory and Consumer Acceptance

Microalgae-based products face regulatory hurdles in many regions, as novel foods often require extensive safety testing and approval before reaching the market. Additionally, consumer education and acceptance remain crucial. While plant-based meat analogues have gained popularity, consumers may need time to fully embrace microalgae as an ingredient in meat substitutes.

Future Directions and Opportunities

Hybrid Meat Analogues

A promising approach involves the development of hybrid meat analogues that combine microalgae proteins with other plant-based proteins (e.g., soy, pea, or wheat). Hybrid products offer the potential to improve the texture, flavour, and nutritional profile of meat analogues while leveraging the unique benefits of microalgae.

Improved Strain Development

Advances in strain development through genetic engineering and selective breeding can lead to microalgae species with improved protein content, flavour profiles, and functional properties. Ongoing research in this area could make microalgae-based meat analogues more competitive with other plant-based proteins.

Sustainability and Circular Economy

Microalgae offer a sustainable solution for the production of meat analogues, as they require less land, water, and energy compared to conventional agriculture. Additionally, microalgae can grow in a variety of environments, including wastewater, providing opportunities for integration into circular economy systems. The development of closed-loop cultivation systems, where microalgae are grown using waste streams from other industries, holds great potential for reducing production costs and environmental impact.

Conclusion

Microalgae-based meat analogues represent a promising alternative to conventional meat products, offering high nutritional value, functional properties, and sustainability. While challenges related to sensory appeal, cost, and scalability remain, advances in processing technologies, strain development, and formulation are paving the way for wider adoption of microalgae-based ingredients in the food industry. As consumers continue to seek healthier and more sustainable protein options, microalgae-based meat analogues are well-positioned to meet the growing demand for alternative proteins in the global market.

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EXTENSION, MITIGATION AND ADAPTATION STRATEGIES OF RICE CULTIVATION IN CHANGING CLIMATIC SCENARIO

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Introduction

India is agriculture dependent country because 2/3rd of its population depends upon agriculture for their survival and it contributes approximately 13.5% to India's GDP. In this climate change era, agriculture is the most threatened sector because of its dependency on local weather conditions. Climate change consequences include melting of glaciers, more precipitation, extreme weather events and shifting seasons (Nelson, et al., 2009). Climate change is believed to affect agriculture by inducing changes on farmers' behaviour, quantity, quality, cost of production, changes in production, consumption, prices, and trade patterns, changes in market responses at global and local levels. These changes not only depend on the domestic and global adaptive capacity but also their economic impact also varies by region, by sector, and by stakeholder groups (Walthall, et.al 2012). Majority of Indian farmers are small and marginal and declining land holding day by day make them more vulnerable to climate change. So climate change is a stressor to achieve the goal of food and nutritional security. Climate change is a challenge for sustainable development. It affects all the sectors directly or indirectly. It refers to any change in climate over time, either due to natural variability or as a result of human activity (IPCC 2007).

The United Nations Framework Convention on Climate Change (UNFCCC) defined climate change as change in climate which is attributed, directly or indirectly, to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Anthropogenic induced climate change is being realized all over the world and has resulted in increased global surface temperature by 0.85 °C over the past 100 years. It is predicted to increase further by at least 1.5 °C by the end of the 21st century (IPCC, 2014). Poverty and disadvantage have increased with recent warming and are expected to increase for many populations as average global temperature increase from 1 °C to 1.5 °C and higher (IPCC, 2018). Future risks at 1.5 °C of global warming will depend on mitigation pathway and on the possible occurrence of a transient overshoot. Larger risks are expected for many regions and systems for global warming at 1.5 °C, as compared to today, with adaption required now and up to 1.5 °C. In general, it was found that the effects of climate change on agriculture will be felt most in the developing world and in least developed countries. In India, agriculture is the main source of livelihood for almost 60% of the country's total population. The impacts of climate change on agriculture will therefore be severely felt in India. It affects the crop yield both positively or negatively by contributing to changes in agricultural inputs like irrigation water, amount of solar radiation that affect crop growth, soil condition and prevalence of pests and diseases. Temperature and rainfall are the most important factors that affect plant growth, development and yield. So any change in the climate will adversely affect the productivity of major crops through changes in the phonological process of the crops. It has been projected that under the scenario of a 2.5 °C to 4.9 °C temperature rise in India, rice yields will drop by 32%-40% and wheat yields by 41%-52%. This would cause GDP to fall by 1.8%-3.4% (GoI 2011; Guiteras 2007; OECD 2002).

In most of the cases climate change results in changes in plant which cause stress on them i.e., abiotic stress and biotic stress. Among abiotic stress, Heat stress, drought, salinity and submergence are the foremost threats. Due to this, knowledge and adaptation to climatic variability has drawn attention at global level with the rise in climatic events along with increasing confidence in climate change projection (IPCC, 2014). Extension and adaptation strategies helps in adjusting agricultural activity and management practices towards the existing or predicted climate conditions to reduce the vulnerability and ensures climate-resilient farming systems (Shameem et al., 2014). Adaptive capacity is an important attribute as it describes system's capacity to mobilize resources to respond, recover from, and maintenance functions in response to stresses and shocks. The ability of agriculture to adapt and cope up with climate change depends on factors such as water resources (Shukla et al., 2019), farm technology

(Meena et al., 2019), access to inputs (Jha and Amarnath, 2011), crop varieties adapted to local conditions (Bhatta and Aggarwal, 2015), access to knowledge, infrastructure, agricultural extension services, rural financial markets, economic status and wealth (Panda, 2016), etc. To cope up with these unprecedented changes in climatic phenomena, appropriate extension, adaptation and mitigation strategies need to be developed. In this article we will majorly discuss on the different strategies to combat the effect of climate change that can alter the phonological growth of the crop and hamper the productivity.

Projected Impact of climate change on rice cultivation in India

In India, climate change will reduce rice yield by 3 to 5% under medium emission scenario and 3.5 to 10% under high emission scenario (Palanisami et al 2017). According to another study, change in temperature and rainfall in India will reduce the yield of rice by 15-25% (Kavikumar and Parikh,1998). According to Singh et al 2010, increase in temperature by 2.5^{o}C during vegetative and reproductive stage of rice can reduce the yield of grain by 23 and 27% respectively. But one important aspect in this regard is, these all estimates focus on yield reduction only; not variability in yield. Like, some of the studies also concluded that there might be possible net increase in production due to increase amount of CO2 in the air. Most of the studies does not addressed the climate change impact at regional level. According to these types of studies, it is generally assumed that, in case of south India, there may be slight increase in production under both medium and high emission scenario. In case of eastern India also, this type of trend can be seen. But in case of north India and central India, there will be decreasing trend in total production. So, the overall impact will be going to be negative in all over the India.

Viable Extension and Adaptation strategies in changing climatic scenario

To counter the anticipated impact of climate change, extension, mitigation and adaptation strategies must be strengthened.The possible solutions to combat against this type of problems the important extension and adaptation strategies is is given below;

Cultural Strategies

A. Efficient water use

Cycle, periodicity, and intensity of rainfall during the monsoon determine the fate of rice farmers and this cycle is changing due to climate. The declining availability of water and increased competition from domestic and industrial sectors are affecting the sustainability of rice cultivation. Many districts in the rice-growing areas of the northwestern IGP show a groundwater table decline of 3-10 m year-1 during the last two decades. Water application in rice needs to be decreased by increasing water use efficiency. The various management and adaptation options for high efficient use of rain water include;

i. Diversified cropping

ii. Crop scheduling

iii. Construction and maintenance of small ponds to be used as reservoirs for rainwater harvesting.

iv. Water-saving techniques

v. Alternate wetting and drying

vi. Shifting away from continuously flooded (anaerobic) to partly or even completely aerobic rice.

vii. Initiate a movement like 'more crop per drop of water', which has been quite successful in Israel.

viii. Aerobic dry-seeded rice: one such option to minimize the water requirement of the rice crop. It helps in attaining 20-30% savings of irrigation water.

ix. Direct-seeded rice

B. Integrated practices

To reduce the emissions of GHGs in rice production, integrated practices are needed. This would be possible through integrated crop management strategies involving best management practices, such as;

I. Altering planting time

II. Integrated nutrient management

III. Integrated pest management systems.

IV. Use of resource-conserving technologies, including zero- or minimum-tillage with residue mulch

V. Judicious use of pesticides

VI. Use of biotechnological approaches, such as bioremediation using fungi, bacteria, and other microbes, may help in alleviating pollution.

VII. Phytoremediation: involving the use of high latitude terrestrial plants could be another option for the remediation of polluted soils.

C. Genetic Strategies including breeding for pest and disease resistance

Genetic strategies for coping with the adverse effects of climate change can be designed, taking advantage of the natural variation available in the germplasm and alien genes accessible from different biological sources. Therefore, it is essential to tailor new varieties that can adapt to the adverse effects of climate change and still have high yield and at the same time crops are required to be disease, resistant, as a wide range of fungal, bacterial and viral pathogens that affect the yield of cultivated crop species, especially in tropical climates.

(i) It enhances the production of food by reducing dosses due to diseases.

(ii) Reduces the dependance on fungicides and bacteriocides.

D. Sowing of Varieties suitable for various abiotic and biotic stress conditions

Abiotic stress such as, drought, high soil salinity, heat, cold, oxidative stress and heavy metal toxicity is the common adverse environmental conditions that affect and limit crop productivity worldwide. Use of a promising alternative strategy to overcome the limitations to crop production brought by abiotic stress and for better plant health and protection because they are environmental friendly, cost-effective and can also provide protection against biotic stresses. The possible extension and adaptation strategies have been given below;

Sl.No.	Situation	Suitable varieties
1.	Salinity tolerant rice varieties	DRR Dhan 39,CSR 46,CSR 56,CS 52 and CSR 56.
2.	Drought tolerant rice varieties	MTU 1010 , Pant Dhan 16, Shabhagidhan, Indira BaraniDhan-1,CR Dhan 40,CR Dhan 20 2 and DRR Dhan50.
3.	Heat or High temperature tolerant rice varieties	DRR Dhan 47 and DRR Dhan 52
4.	Low Temperature requiring rice varieties (Cold/Frost)	Kalinga 1, Pant Dhan11 and Varun Dhan.

5.	Sowing of early or late maturing rice varieties	DRRDhan 44, DRR Dhan 42 and DRR Dhan 47.
6.	Varieties Suitable for Aerobic Rice Conditions	CR Dhan 201,CR Dhan 200,CR Dhan 203, CR Dhan 204 , CR Dhan 205, CR Dhan 206 , CR Dhan 207,CR Dhan 209 and CR Dhan 210
7.	Sowing of water-logging/flooding/submergenceS tolerant varities	Sabour Shree,CR Dhan 802(Subhas),CR Dhan 500,CR Dhan 505, Samba sub-1and Jalamani

E. Precise and better agronomic approaches

i. Modified SRI

This is slightly modified the practiceusing a fibre-bodied 8-rowed paddy seeder (drum seeder) for sowing the seeds and modified the weeder in such a way that it runs between the space in (20 cm) between the two paddy rows,”. An additional advantage was reduction in cultivation cost. It helps in reducing the cost of cultivation up to Rs.4,000-5,000 per acre in this method due to skipping of practices like nursery raising and manual transplanting. Duration of the crop is also reduced by 7-10 days in modified SRI method compared to conventional practice.

ii. Direct seeding of rice

Rice can be directly seeded either through dry or wet (pre-germinated) seeding. Dry seeding of rice can be done by drilling the seed into a fine seedbed at a depth of 2-3 centimeters. Wet seeding requires leveled fields to be harrowed and then flooded (puddling). The field is left for 12-24 hours after puddling, then germinated seeds (48-72 hours) are sown using a drum seeder. Seed can be broadcast for either dry or wet seeding, but manual weeding is more difficult. Indeed, weed management is a critical factor in direct seeding. Timely application of herbicides (timing is dependent on the method of seeding) and one or two hand weeding provide effective control. The varieties suitable for DSR is Shabhagidhan.

iii. Alternate wetting and Drying technique

'Alternate wetting and drying' (AWD) is a water management technique, practiced to cultivate irrigated lowland rice with much less water than the usual system of maintaining continuous standing water in the crop field. It is a method of controlled and intermittent irrigation. A periodic drying and re-flooding irrigation scheduling approach is followed in which the fields are allowed to dry for few days before re-irrigation, without stressing the plants. This method reduces water demand for irrigation and greenhouse gas emissions without reducing crop yields.

iv. Community nursery management

Establishing a staggered community nursery as a local extension and adaptation strategy at the village level to combat the problem experienced by farmers during deficit rainfall seasons in lowlands. The technique involves raising a staggered community nursery under assured irrigation in the village at an interval of 2 weeks. In the anticipation of a two weeks delay in monsoon the first nursery is taken up as a contingency measure by 15 June with the long duration variety (>140 days) in order to transplant 3-4 weeks old seedlings by first fortnight of July. If the monsoon delay extends by 4 weeks, the second nursery is raised with medium duration varieties (125-135 days) by 1st July to supply 3-4 weeks old seedlings for transplanting in the 3rd or 4th week of July. In case of anticipation of further delay or deficit rainfall conditions, the 3rd nursery is raised by mid July with short duration varieties (<110 days) to take up transplanting of 3-4 week seedlings in the first fortnight of August.

v. Staggered planting

Thee practice of transplanting rice seedling at different days having different ages is termed as staggered planting. The age of seedling is an important factor because it has tremendous influence on the growth and development, tiller production, grain formation and other yield contributing characters of rice. For optimum yield, age of seedlings at transplanting of a suitable variety at a particular season may not be suitable for other varieties at another season. The use of over aged seedling ultimately affects the general performance of crop and the yield of the crop reduces drastically.

vi. Optimization in seed rate according to situation

Optimization of planting seed rate are of prime importance to determine crop yield as an extension and adaptation strategies to combat climatic variability.

vii. **Better nutrient management practice**

Better Nutrient management practicesrefers to the efficient use of crops to improve productivity. It is necessary to balance the soil nutrient input with the crop requirement. If the nutrients are applied at the right time and in adequate quantities, optimum crop yield is obtained.

- ❖ Use of coated fertilizer
- ❖ 4R nutrient stewardship
- ❖ INM
- ❖ Use of more organic matter in soil
- ❖ Crop rotation
- ❖ Crop residue management

Conclusion

Therefore, it is essential to tailor new varieties and follow above extension, mitigation and adaptation strategies to overcome the adverse effects of climate change and still have high yield of rice crops.

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AZOLLA FERN: CULTIVATION, NUTRITIVE VALUE & SIGNIFICANCE

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Abstract

Climate change, pollution and urbanization led to depletion of nutritious feed for the animals, thereby decrease in the quality and quantity of their production. Many alternatives came into light but Azolla got the attention as a better solution for this problem. Once farmer learn how to cultivate this fern, it becomes a continuous feed source for animals. Abundance of nutrients, no visible negative effects as a feed and it's nitrogen fixing ability shows its potential for sustainability, as a low cost production strategy and promoter of healthy production. Azolla is a livestock, poultry, fish feed; Bio fertilizer / Bio-manure etc., as a better unconventional feed alternative it reduces the competition and protein demand between livestock, poultry for quality feed (due to feed scarcity).

Keywords: Green Moss, Un-Conventional Feed, Integrated farming, Manure.

Synonyms – Green gold mine, Feathered mosquito fern, Fairy moss etc.

Introduction

Azolla is a aquatic free floating green fern belongs to the family Salviniaceae. The name Azolla is derived from the Greek words azo (to dry) and allyo (to kill), and it refers to the plant's inability to thrive in dry conditions (Gamachis Korsa *et al*., 2024). There are at least eight species of Azolla worldwide; *A. Caroliniana, A. Circinata, A. Japonica, A. Mexicana, A. Microphylla, A. Nilotica, A. Pinnata* and *A. Rubra*. The common species of Azolla in India is *Azolla pinnata* (P Mooventhan *et al*., 2019). The most important variety is *Azolla pinnata*, which can be grown easily and with a low initial investment. It is commonly found and grows naturally in the stagnant water of canals, ponds, drains, rivers, and marshy lands in the tropics and subtropics (M. H. Abou El-Fadel *et al*., 2020).

Nutritive value

Azolla produces more than 4 to 5 times of protein of excellent quality in comparison to lucern and hybrid napier. Besides this, the bio-mass production is almost 4 to 10 times when compared with hybrid napier and lucern, respectively. Hence Azolla can be rightly called the "super plant" (P Mooventhan *et al*., 2019).

According to study by Cherry DM *et al*., 2014; The dry matter (DM) content of sun dried azolla meal was 89.73 percent. It contained 75.73 percent organic matter, 23.49 percent crude protein , 14.7 percent crude fibre, 3.7 percent ether extract, 24.26 percent total ash, 7.94 percent acid insoluble ash, 2.58 percent calcium and 0.26 percent phosphorus.

Feeding Azolla and level of Inclusion;

For Ruminants – Azolla is an unconventional feed and cheapest source of protein can be incorporated in the diets of ruminant up to 20% which enhance nutrients digestibility and animal performance. Also, several studies found that fresh Azolla can be used as feed supplement up to 2 kg/day/animal or as replacement dried Azolla up to 20% from commercial feed for dairy cows and buffalo which saved 15–20% of commercial feeds and increased milk production from 7 to 20% (El Naggar *et al*., 2022). Feeding 5% dried Azolla instead of feeding a mixture of concentrate feed in heifers diet aids to improve feed conversion efficiency (FCE) by 20% and average daily gain by 15.7% (Debashis Roy *et al*., 2016).

Azolla at 20% levels for goats showed better body weight change compared to the control group and was economically profitable (Jyoti Kumari *et al*., 2021). According to study by H.A. Ahmed *et al*., 2016; They concluded that azolla can be added in the diet of growing sheep at 6% level replacing linseed cake without any adverse effect on the performance of the animals.

For Rabbits – dried azolla could be included up to 20% level (V. Ramesh *et al*., 2011).

For Pigs – level of Inclusion vary according to stage of growth and physiological status. Azolla pinnata is unconventional protein source 15% in diet reduces the feed cost in swine rearing. (Dr. KPS Saini *et al*., 2020).

For Poultry – for laying hens up to 10% (Khatun *et al*.,2008); up to 7.5% in the diets of broiler (Kumar *et al*., 2018). Azolla meal could be incorporated in quails' diet up to 6% (A

Varadharajan *et al*., 2019). For white Pekin broiler duck farming 5 or 10% level of azolla can be included in the diet (Acharya P *et al*., 2015).

For Fishes – less than 25% in fish nutrition (Nor Anis Nadhirah Md Nasir *et al*., 2022).

Other animals: for horses, Guinea pigs, other poultry species etc. azolla can be fed.

How to cultivate?

Requirements: Azolla is easily propagated but requires abundant standing water, relative humidity of 85-90%, pH of 4.5-6.5, salinity between 90-150 mg/L and adequate phosphorus for its nutritional needs. It is labour intensive, grows fast. Azolla doubles its weight in 3-5 days. From a start of 1t/ha, it can reach a fresh weight of 15-20 t/ha in about 20 days (Sunil Dutt Choudhary *et al*., 2020).

Procedure

A) Making a Pit/Pond (Primary step); elevated location without water stagnancy is required. Cement ponds or HDPE ponds are commonly prepared. Size, shape and capacity of pond may vary based on budget, requirement & no.of animals.

Common Pond Dimensions: 2 M length × 1 M width × 0.5 M depth

Cement ponds can be prepared by making a pit or can be constructed over the land (elevated). HDPE pond setup is readily available can be placed over the soil. Once the pond is ready, for cement ponds base should be covered with polythene sheet. Water leakage should be checked thoroughly for both type of ponds.

B) Preparation of Base; Pour sieved fertile soil to in to floor of pond as a uniform layer and add slurry prepared from cow dung (2-4 kg) and 40g of Super phosphate in to it. Fill pond (about ¾ th) with good quality water.

C) Add mother azolla culture into the pond evenly, sprinkle little water on it so that azolla ferns will set upright.

D) Harvest; with in 10days the pond will be fully covered with azolla and it is ready to harvest (regularly as per requirement).

E) Every week add slurry prepared from dung (600-700 g), Super phosphate (20 g), mineral mixture (1 table spoon). Water should be added when water quantity is reducing. Re-change the culture for every 6 months (remove the fern completely, dry the pond, clean the sheet and re-do the procedure).

Precautions

1) Regular water change is required and quality should be monitored.
2) Proper maintenance and regular harvesting is necessary to maintain the yield.
3) Direct sun should not fall on the fern so, azolla ponds should be covered with shade green net or shed should be placed over the pond.
4) Minimum amount of water (about half of pond capacity) should be maintained continuously.

Uses

1) Decrease in cost of feed per animal required, thereby cost of production.
2) Improvement in growth and performance traits.
3) Decreases the use of fertilizers and chemicals in production.
4) Mother culture is quite low in cost and can be easily maintained.
5) Readily available feed in our backyard even in low rainfall and dry areas.
6) No harmful effects if given to animals in recommended levels.
7) Very nutritious feed – contains Minerals (zinc, calcium, magnesium etc.). and Vitamins (Vitamin A precursor – Beta carotene & Vitamin B12), they improves the health, reproductive performance of animals and production (up to 15%).
8) Increased profit / returns.

Limitations

1) Lack of land available for construction of ponds.
2) Poor availability of resources in rural and remote areas.
3) Water scarcity and pollution.
4) If carelessly maintained, there is decrease in yield so it requires continuous attention.
5) Extreme temperature can retard the growth (it's not in famers hand, can only regulate temperature for some extent).
6) Lack of awareness among small and marginal farmers.
7) If over fed can cause digestive disturbances.

Key Notes

How to feed azolla: can be given as fresh green fodder or after sun drying, alone or by mixing with concentrates. It is recommended that to make the animal habituated to this new feed, little quantity can be mixed to concentrate feed in initial days and later on increase the inclusion level of azolla. Once the animal is habituated withdraw mixing with concentrates & can be given as such. Level of inclusion should be maintained as recommended.

Remember azolla can only be given as feed supplement and farmer should not withdraw any fodder (& bulk) that will be provided to the animal usually. If farmer want to do any changes in feeding pattern, it's recommended to get a opinion and consult from specialist.

Adding azolla to paddy field**:** Blue-green Algae & Azolla has Symbiotic relationship. It fixes atmospheric nitrogen about 25 kg/hector thereby increases the crop yield.

Azolla in Integrated farming: Initially use of azolla was limited to paddy fields as nitrogen fixators, but now with research showing potential as an unconventional feed has increased the value of this fern. It plays a key role in success of integrated farming, as nitrogen fixator, decrease the weed growth and increase in the yield and also as a feed (from ruminants to poultry) can decrease the cost of production and increases profit returns.

Scope: Climate change and lack of quality fodder is going to further worsen in upcoming decades. Azolla is showing promising results in both agriculture and animal husbandry in this matter. The potential and use of azolla may increase in future and start-up business as azolla supplier for mother culture and for daily feed to other famers can be good business especially in semi-urban areas.

Conclusion

Extension activities for farmers are necessary to make them understand what the benefits of azolla are and how to make profit out of it. Proper utilisation of this fern as unconventional feed and in agriculture as Bio-manure will give good returns to the farmers and also promotes healthy production.

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GEMS OF THE SEA: PROFITABLE VENTURES IN PEARL FARMING

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Introduction

The growing demand for cultured pearls has made pearl farming a popular and profitable venture in India, owing to the low investment required and high returns. Pearls are in great demand in the national and export markets. You can easily adopt pearl farming along with fish farming and other commercial aquaculture activities. Talking about pearl farming profits, you can expect to earn 50-60% of what you invest. Moreover, if you get the right pearl farming training and equipment, you can expect to earn 100% profit – but it is a long way.

What is pearl farming

Pearl farming is a process of cultivating freshwater grown pearls on a farm. For about 2-5 years, farmers take care of the oysters to develop them.

Benefits of Pearl Farming in India – Why One Should Grow Them

99% of all the available pearls are cultured pearls. They are obtained by cultivating them through mussels and oysters. Also, Odisha ranks first in terms of pearl farming in India.

Here are some of the benefits of pearl farming in India

1. Has a high market value

The best part about pearl farming is that these natural gems are in great demand. Unlike gold and silver, their prices do not fluctuate frequently. Cultured freshwater pearls cost around Rs 250 per gram. While the price of cultured saltwater pearls in India is around Rs 450 per carat.

2. Easy maintenance and storage

Once cultured, these light-weight pearls can be kept for any period of time. They are highly non-perishable. And can be used to make jewellery or decorate clothes any time.

3. Low Labor Cost, High Employment

Pearl farming is less labour intensive as the process is structured and requires limited manpower. Which, in turn, reduces the labour cost greatly. And if you acquire the best skills and knowledge from a pearl farming training institute, the chances of getting employment are quite high. And since this type of commercial farming gives a lot of profit, the income allocation is also quite high.

4. Minimal Expenses and Inputs Required

Pearl farming requires limited setup and investment costs. The resources, inputs or methods are easily available at minimal expense. With the right training of pearl farming business in India, you can learn to plan resources and optimize their costs. With prudent planning, you can make the most of your invested amount.

Best Pearl Farming Training in India

CIFA (Central Institute of Freshwater Aquaculture) under the Indian Council of Agricultural Research offers national training on "Freshwater Pearl Farming". This training helps small marginal farmers to develop the entrepreneurial skills required to set up a business for freshwater pearl farming in India. There are other recognized pearl farming training institutes that offer complete technical training about pearl farming. Here is the schedule showing the names of popular training institutes in India. You can inquire about pearl farming training fees and the concepts they teach.

Training Center Location Training Duration

1. Marathwada Pearl Culture (MOTI) and Training Center Aurangabad- Short Term
2. Freshwater Pearl Farming Training Institute Jaipur-6 Weeks
3. Wizard Pearl Farming Center Haryana-2 Days (Practical + Theoretical Application)
4. Swastik Pearl Farming and Training Center Uttar Pradesh-10-15 Days
5. Pearl Farming Training (Krishi Vigyan Kendra) Chandangaon, Madhya Pradesh-Not Available
6. Pearl Farming Training and Research Alwar, Rajasthan-Not Available

How to start pearl farming

There are some steps to start pearl farming. Let's review these steps to help you further improve your pearl farming business plan.

Step 1 – Site selection and pearl farm setup

You need to select the site and get its water approved from government-approved laboratories. CIFA-approved laboratories are ideal because they are genuine and reliable. Their testing will help you decide if the water quality is good for pearl farming.

Step 2 – Obtaining pearl oyster stock

After site selection, it is important to obtain oyster stock through the following methods

Spat collection In this method, you can collect young swimming oyster larvae called spat. These larvae are at the perfect stage for grafting and can be easily glued to any surface.

Hatchery production You can also refer to hatchery-produced spat if they are available in your area and at a reasonable price.

Collect adult oysters You can collect adult oysters available at a reasonable price. However, they have a higher risk of mortality.

Step 3 - Drill and Hang the Oysters

Once you have a stock of oysters, place them in an approved water site. You can hang them in a chapel, which is similar to a circlet or rosary. You can keep them in a large net container.

Step 4 - Grafting

You can use the artificial method of grafting to grow pearls. You can implant an artificial nucleus into the tissue of the pearl oyster which will develop into a pearl.

Step 5 – Pearl Development Process

Once you implant the nucleus, it irritates the oyster. And as a result, the oyster covers itself with a calcium carbonate layer. It will take 12-24 months for the pearl to develop. During this transition, take proper care, feed them on time and protect them from any kind of infection.

Step 6 – Marketing the Pearls

Once you have produced pearls, make sure you sell them in the right market. You can endorse them to jewellery, cosmetics and apparel brands. Create a marketing strategy. And if you have a great stock of pearls, you won’t have to bid hard to sell them in the market. Their quality will speak for itself.

Benefits and Cost Analysis of Pearl Farming

• At a low cost, one oyster costs Rs 20-30. And the price of an oyster pearl of 1 to 20 mm can range between Rs 300-1500. Pearls are in great demand in jewellery, cosmetics, paint formulations and decorating clothes.

• The initial investment for pearl farming would be close to ₹20,000 to ₹25,000. With this much investment, you can earn an income of up to Rs 300,000. The return on investment would be 50-60% of the initially allocated expenditure.

• Note that pearl farming is easy to start but requires a long-term commitment. You have to be patient enough and wait for a maximum of 5 years to see a steady income.

Cost variables involved in pearl farming

• Cost of obtaining oysters through 3 popular methods – spat collection, purchase of hatchery-produced spat, and collection of adult oysters.

• Cost of buying a boat.

• Types of equipment and supplies.

• Labor cost

• Cost of buying SCUBA gear.

• Set up cost for farm structure (lines, rafts, floats, etc.).

• Technical consultant's fees

• Marketing expenses

• Grafting technician's cost

• Licensing cost

• Licensing cost (if you want to grow it commercially)

• Cost estimation for pearl farming – Let's estimate

Requirements

• Pearl farming project area- ½ to ¾ acre

• Culture technique for pearl farming Double implantation

• Density for stocking 9,000-10,000 mussels

• Timeline for culture 15-18 months

Subsidy for pearl farming in India

As a part of the Blue Revolution scheme in the fisheries sector, the central government will provide subsidy to Indian fisheries. The subsidy amount will be 50% of the total cost of setting up the pond for pearl farming. The aim of this subsidy is to help farmers increase their income. By investing Rs.25000 farmers will be able to earn an income of up to Rs.3,00,000.

Eligibility, Documents and Application Process for Pearl Farming

The applicant must be an Indian citizen and a farmer by profession. He must gain knowledge through pearl farming training in India.

The following documents are important for subsidy application:

- Residence Certificate
- Category Certificate
- Aadhar Card
- Bank Account Details
- Pond Area and Farming Details
- Passport Size Photos
- How to Farm Pearls at Home?

How to Farm Pearls at Home?

You can easily farm pearls in a bucket or fish tank at home. This process is called recirculating aquaculture system. There are a few steps you need to follow to start pearl farming at home. Arrange two fish tanks, and place them one above the other. Drill a hole in the top tank so that water can flow into the bottom tank. Add an air pump that will regulate the water flow and temperature. The pump system, once fitted, should run for a few hours in the morning and evening for 7 consecutive days. Make sure the size of the single tank is length - 3 feet, width - 2.5 feet and depth - 1.5 feet. This size can easily accommodate 50 mussels at a time. Give the mussels the required minerals and vitamins. Make sure the algae you are giving to the mussels is of good quality. Because their quality will affect the quality of the pearls that are grown in the end. As per an estimate, it will cost you a maximum of Rs 20,000 to set it up. This is a good investment, considering the amount of profit you will get in the end. Please note that if you are planning to trade pearls commercially, you should apply for a license. Licenses and registrations required to set up a pearl farm Permission from fishermen’s cooperative society Certificate from CIFA (Central Institute of Freshwater Aquaculture) GST registration Land and lease agreement conclusion Pearl farming in India is commercially viable and profitable. Given the demand for pearls, high employment, and huge returns, pearl farming is the next best option.

Pearls are in great demand even outside the jewellery sector. They are also in equal demand in the cosmetics, pharmaceuticals, and textile industries. With proper licensing and pearl farming training, you can create a profitable business model. However, note that pearls take 12-

24 months to grow. So initially, you have to be patient to start trading it. And make sure you calculate your costs as mentioned above to avoid any sudden expenses. On a single project with time, dedication, and resources, you can earn up to 50-60% return.

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CARE AND MANAGEMENT OF DAIRY CALVES - FROM BIRTH TO WEANING

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Introduction

Calves are regarded as the future dairy herds. Proper care and management of the young calves is crucial for the success of any dairy farming enterprise as 70% of the calves dies due to improper management. It is therefore essential to rear the calves economically ensuring early maturity, minimizing calf mortality and improving their welfare. Calf mortality particularly in the first month should be kept below 5% by proper management including adequate feeding practices. Unlike the management of larger growing stock or lactating cows, where management lapses can reduce growth rates or milk production, even small mistakes with the very young calf can cause death resulting in reduced profitability. Milk suckling phase is a vital period in a calf's life, during which the calves require additional care and attention in order to increase milk production. Since, the dairy cow inherits her milk producing ability, it is important that the dairy farmer raises only the heifer calves from high yielding cows. Moreover, the health of the calf, the development of its digestive tract and growth and development of its body during this period will influence subsequent performance.

Neonatal calf care immediately post-partum:

- Immediately after birth, remove any mucous or phlegm from the nostrils and mouth using a clean dry cloth to facilitate normal breathing.
- Normally the cow licks the calf immediately after the birth. Licking can also be induced by sprinkling a small amount of common salt on the calves' body. This helps to dry off the calf and stimulates breathing and circulation. It also prepares the calf to standup and walk.

- If the calf does not start breathing, provide artificial respiration by alternate compression and relaxation of the chest or hold the calf by the rear legs and lift from the floor with the head down and swing it. Care should be taken so that the calf is not slipped out of hands.
- The next step is the disinfection of navel cord. The navel should be tied about 2-5cm away from the body of the calf and cut 1cm below the ligature and apply tincture iodine or boric acid or any antibiotic for 2-3 days to prevent local infection. It is necessary for the prevention of navel-ill, joint-ill and calf scour.
- Remove all the wet bedding from the cow pen and wash cow udder with clean water and dilute potassium permanganate solution.
- If the calf born was normal it would stand on its leg and suck within 30 minutes. If fails assistance should be given in getting first feeding.
- Normally meconium (dark material that have collected in the intestine of unborn calf) passes within 2 hours after the first feed. If this does not pass in due time, enema consisting of one and a half tea spoonful of sodium bicarbonate in a litre of warm water should be given.

Colostrum feeding

- Colostrum is the first milk given by the cow after calving. It contains much more protein, ash, carotene and vitamin A which ensures better growth.
- It has laxative properties which helps to clear the digestive tract of faecal material and contains gamma globulins which are nothing but antibodies that protect the calf from several calfhood diseases.
- It is essential that the new born calf should receive 10% of their body weight, the fresh, creamy colostrum during its first 24 hrs of life. The calf needs 3-4 litres of colostrum daily in 3 equal feeds.
- If no colostrum is available due to death of the dam or some other reasons, the calf may be fed with normal milk from another cow, but this should be supplemented daily with 20ml of cod-liver oil or any other source of vitamin A.
- If there is any simultaneous or recent calving within 4 days, colostrum from such cows may be fed to the unfortunate calf.

- The cows from the same herd secret almost identical types of antibodies in colostrum.
- When only plain milk is available and there is no other alternative other than feeding plain milk, 50ml of castor oil may be given to compensate for the laxative effect of the colostrum.
- The newborn calf will not be able to drink the entire colostrum from the dam at this tender age. So, the excess colostrum should be milked out.

Whole milk feeding to calves:

- After the colostrum feeding period, the calves can be fed with whole milk or quality milk replacers. As far as possible provide milk from the calf's mother.
- In neonatal calves, suckling stimulates the oesophageal groove, a muscular tube that contracts as a reflex during normal milk feeding. This direct milk into the abomasum, bypassing the rumen, reticulum and omasum.
- If feeding is rushed, or the calf is stressed, the reflex can fail and the milk will enter the rumen where it ferments, causing digestive upset and scouring.
- Whole milk or milk replacer should be fed at the rate of $1/10^{th}$ of the body weight preferably in two doses for the first 90 days after the colostrum feeding period.
- Milk-replacer is offered to the calf by mixing one part with 8 parts of water. Correct proportion should be fed as too weak or too strong solution tends to create digestive issues.

Separation of cow and calf:

- Usually, calves are separated from their mothers within few hours of birth. However, in natural conditions, calves stay close by their mothers until two weeks of age, and slowly distance themselves until being completely weaned at six to eight months of age.
- Early separation is less distressing to both the calf and dam, and it also minimizes the amount of bondage between the two.
- Although some bonding can occur within the first five minutes of life, the bond only gets stronger as long as the cow and calf stays together.

Weaning:

- Weaning is the practice of removing the calf from the dam. Most dairy calves are weaned from cows immediately after calving or within 3 or 5 days (early weaning).
- In most of the cases, calves will only be weaned after the milk feeding is completed.
- The primary criteria for determining weaning of calves are age, grain intake and body weight gain.
- In a dairy farm, depending on various factors and preferences, calves are weaned between 4 to 8 weeks of age. The most important point is that the calf should be healthy enough before weaning and should be able to consume at least 0.5 to 0.8kg of concentrate in a day.

Advantages of weaning:

- It helps in ensuring clean milk production.
- We can properly record the milk produced by the cow for future selection and progeny testing.
- Calves can be fed with milk-replacers, thus saving milk for human consumption.
- Adequate measured quantity of milk can be given to the calf, thus preventing under-feeding and over-feeding.
- Helps prevent injury to the teat
- Helps to control mastitis.

Disadvantages of weaning:

- Weaning have drawbacks as well. For instance, in buffaloes and zebu breeds of cattle, weaning of calves will lead to certain behavioural problems due to the strong maternal instinct in these animals.
- The abnormal behaviours include nervousness, restlessness, highly temperamental, may not allow milking, goes off-feed, frequent bellowing and searching of the calf.
- In such cases, weaning may cause reduction in milk yield and also early drying off.

Training of calf for pail feeding:

- Feeing management can be made easier by training the weaned calves to drink milk from pails.
- The longer a calf sucks its mother the more difficult it is to drink milk from an ordinary pail.
- The measured quantity of boiled and cooled milk poured in the milk pail and should be moved to the calf. Care should be taken to avoid frightening.
- The calves should not be forced to drink milk by immersing the head into the ball. Frightened calves may refuse to come close to the pail.
- The attendant should first dip his two fingers (index and middle fingers) into the milk after cleaning and kept close to the mouth of calf.
- After tasting the milk calf will start suckle the fingers.
- Gradually the fingers should be lowered to the pail and should be dipped into the milk.
- When the calf takes one or two mouthfuls of milk remove the fingers.
- This process may be repeated whenever the calf stops drinking and lifts its head.
- Usage of nipple pail is more advantageous than the open pail, as drinking the milk more slowly will cause the milk to go directly to the abomasum rather than to the rumen.

Housing of calves:

- Within the first 24 hours of life calves should be removed from the dam and housed alone in a clean, dry and warm environment where they can adapt the external world.
- A proper housing and bedding is essential for the calves as the housing conditions of the livestock greatly affects their health and productive performances. Besides the calves are more prone to diseases as their immunity level is low and growth rate is also affected.
- Further exposure to extreme climatic variations such as extreme heat and extreme cold leads to physical stress and the body of calves is not adapted to bear such stress and the calves may collapse.
- Having a sustainable housing environment for the calf is beneficial to their thermal, physical and behavioral comfort.

- Calves should be housed individually to minimize the spread of diseases and reduce pathogen transmission.
- Isolated housing provides easier observation for the calf feeder to maintain the health and provide any necessary medical attention for each individual calf.
- Physical comfort is the second most important aspect of the calf's environment focusing on the quality and conditions of the space available. The open space should be approximately 32 square feet of space for calves to be able to exercise and move around their pen at their leisure.
- Calves spend much of their time lying down especially at younger ages, therefore, the dryness and cleanliness of their resting area is important.
- Behavioral comfort is the last vital quality in sustaining the environment in which calf is housed. Feed and water should be easily accessible for the calf to minimize any frustrating situations.

Feeding of calves:

- Start training the calf to take concentrate and roughage after one week of age. Solid food stimulates rumen development.
- In calves, reticulo-rumen is non-functional and they cannot utilize roughages containing higher amount of cellulose.
- Hence, high quality hay should be fed to calves from the beginning to encourage the early development of rumen and reticulum.
- Calves should be fed twice or more times in a day. One time feeding may cause indigestion and diarrhoea results in dehydration.
- Calves should be liberally fed as they are continuously growing; overfeeding however should be avoided and thorough cleanliness observed in every stage of feeding and general management. Prevent licking in group housing.
- At 1 month of age, the calf can be provided with a good quality calf starter.
- Calf starter is the first concentrate (solid) feed that is given to young calves containing high amount of easily digestible nutrients.

- A calf consumes around 125g by 1-2 months and 250g of calf starter by 2-3months. When the calf starts consuming around 250g of calf starter daily, milk feeding can be completely stopped (weaning).
- Provide good quality green fodder and hay from 4th month afterwards.
- Feeding of antibiotics along with feed additives to calves improves appetite, increases growth rate and prevents calf scours. E.g. Terramycin, aureomycin etc
- Each calf should be treated individually; it should be weighed weekly and feed according to the body weight and growth response.
- In the pen, clean water must be available at all times.

Health and disease prevention:

- Calfhood diseases have major implications on economic viability of a dairy farm.
- Observing calves at least twice daily is extremely important. The calf has to be observed for scouring.
- The complications of calf scours include dehydration that may lead to stunted growth and impairment of immune system resulting in respiratory complications like pneumonia and finally death.
- Calves essentially require a constant supply of readily digestible energy when combating diarrhoea and dehydration.
- Calves should receive ample amount of water till four weeks of age that facilitates adequate consumption of calf starter, lessens few scouring days and accelerates body weight gain.
- Isolate the sick calves and treat them separately.
- Restrict unnecessary movement of persons/outsiders in the calf pens.
- To boost disease resistance provide iron and vitamins A,D & E orally or by injection soon after birth. This is especially useful in weak/anaemic calves.
- Regular and periodic deworming, grooming and dipping or spraying to control external parasites are to be followed routinely.

- Calves should be dewormed in the first week itself for ascariasis. A single dose of 10g piperazine adipate is recommended.
- Deworming should be done every month for first 6 months, thereafter once in three months.
- Over dose and underdose of deworming drugs should be prevented for any side effects.
- Vaccination is necessary to prevent the calves from many infectious diseases especially bacterial and viral diseases.

Dehorning:

- Dehorning and disbudding are adopted in horned cattle breeds.
- Dehorning is essential because horned animals are dangerous to the workers, need more space in the shed and inflict injury on other animals causing economic loss. The dehorned animals are easy to handle.
- Dehorning is done usually at the age of 10 days by which time the horn button becomes attached to the skull.
- Many methods have been used to prevent horn growth in a young calf which includes chemical or heat cauterization.
- Heat and chemical cauterization is used for calves within the first eight weeks of age. Red hot iron or caustic potash stick or electrical method can be used for dehorning in calves.
- Dehorning should not be done during extremes of weather conditions and during fly season.

Other managemental practices:

- Identification of calves is done by tattooing in the ear at birth.
- The body weight of the calf is taken at birth and regular intervals thereafter if possible. Growth under field conditions can also be monitored by taking heart girth. The relationship between these two gives a good indication of growth.
- Extra teats beyond 4 should be removed at 1-2 months of age.
- By 8-9 weeks of age, males should be castrated.

- Mineral-blocks should be provided, so that the calves lick and no changes for mineral deficiency.

Conclusion:

This article mainly emphasizes the absolute care and other routine managemental practices that are necessary for the calves for proper growth and development, significantly to prevent death due to under feeding/over feeding and diseases, such as pneumonia, calf scours, navel infections and worm infestations and to minimize the mortality rate and increase the survivability of the calves and therefore, better economy of dairy farms.

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GOBUZZR – A BEE TRACKER

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Introduction

Gobuzzr is a smart beehive monitoring system that uses IoT(Internet of Things) technology allowing the beekeepers to preserve the honey, hives and colonies even when they are far away. Due to the important role of honeybees in life, there have been increasingly advanced techniques introduced to support apiarists in taking the best care of their bees. Recently machine learning methods are emerging as a powerful tool among these techniques, and have great contribution to automated bee hive monitoring systems with low cost and better performance.

Bees are essential creatures to human life, as they pollinate food crops. They play an important role in the preservation of healthy ecosystems. Apart from food production they enormously contribute to the enhancement of landscapes. However, they face a global crisis characterized by significant population decline, including colony collapse disorder which threatens their survival.

Beekeeping is one of the tasks that need constant monitoring every day, especially during the spring season. It takes a lot of man power and dedication to monitor beehives to keep them safe from any kind of unwanted disturbances. Through this new technology, an apiarist can monitor a hive without manual intervention. Gobuzzr helps to get optimized produce, mitigate risks and take appropriate actions without delay. This technology is used to monitor,

- In-hive temperature
- Real – Time bee health
- Weight of honey production
- GPS to track bee’s location
- External temperature
- Inhive humidity

Dev Beetech India Pvt. Ltd, Tamil Nadu based start-up, has come out with an IoT based product called Gobuzzr which when installed on the bee box monitors details like weight of honey deposited, temperature and humidity of the beehives among others. Mr. G. Kapildev, Founders of the startup explained that ‘traditionally, beekeepers monitor each box manually.

These boxes are kept at different places and moving around takes a lot of time and involves huge cost.Not just that each time before checking the boxes they have to wear a bee suit to prevent getting stung.Alsobeekeepers have to pull out each frame from the box to keep track of the honey. And this takes a lot of time. But now with this technology, all they do is to plug in the device and then they can monitor beehives from anywhere and get the report of all parameters together in a few seconds in their devices.

He also explained that this was an IoT based device communicating to the mobile application via websitebased server. Gobuzzr monitors the weight of the beehive round the clock with the help of sensors in the device. From time to time, the device sends out statistics pertaining to the bee box to the beekeepers.This works similar to a cctv camera which you install and monitor through your mobile devices from anywhere.

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BANANA POST-HARVEST MANAGEMENT PRACTICES IN TAMILNADU: STRATEGIES FOR REDUCING LOSSES AND ENHANCING QUALITY

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Introduction

Banana creation is a chief cultivation crop in India. Bananas are the fifth biggest agrarian product in world exchange after cereals, sugar, espresso and cocoa. Banana is a critical food harvest and it has more noteworthy monetary significance among the food crops, since it is one of the main wares in farming commodities. Bananas are filled in excess of 150 nations, delivering 105 million tons of organic product each year. The worldwide creation of banana is around 102028.17 thousand tons of which India contributes 29.19%. Banana has an expected creation of 27.58 million tons in India which is most elevated on the planet. A degree of 99.95% of this creation is consumed inside the actual nation and just 0.05% creation is sent out. Significant banana delivering states in the nation are Andhra Tamilnadu, Gujarat, West Bengal and practically every one of the southern states. Tamilnadu contributes fundamentally to India's banana creation with a yield of roughly 3.8 million tons yearly. A critical part of food creation is lost after reap because of inappropriate taking care of, stockpiling, and transportation. This can go from 10% to 40% relying upon the harvest and the district. By carrying out appropriate post-collect methods like cooling, drying, and handling, the deficiency of value and amount can be decreased, prompting more prominent food accessibility and monetary returns. Post-reap rehearses are fundamental for save the taste, surface, variety, and healthy benefit of food. Legitimate capacity conditions forestall decay, bother invasions, and pollution, guaranteeing that buyers get excellent items.

HARVESTING PRACTICES

Banana harvesting is a critical stage in the supply chain, as it directly impacts the quality and shelf life of the fruit. Effective harvesting practices ensure that bananas are picked at the right maturity, handled carefully, and prepared for post-harvest processes.

- ✓ Optimal maturity stages for harvesting
- ✓ Harvesting techniques (hand-picking mechanical)

Optimal maturity stages for harvesting:

The ideal development stage for collecting bananas is urgent for guaranteeing great quality, appropriate aging, and limiting post-gather misfortunes. Bananas are typically reaped when they are experienced yet at the same time green, as this permits them to age under controlled conditions after collect. The ideal development stage fluctuates relying upon the banana assortment and expected market (nearby or trade).

Physical Characteristics of the Fruit

- **Finger Totality:** One of the essential signs of development is the completion of the banana fingers (individual natural products). A full grown banana will have stout, adjusted fingers, with diminished rakishness (sharp edges). The more developed the banana, the rounder the fingers become.
- **Precise Edges:** Youthful bananas will more often than not have sharp rakish edges, while mature bananas are rounder, demonstrating that they have finished up and are fit to be reaped.

Days In the wake of Blossoming

- **Blossoming to Reap Span:** The quantity of days between blossoming (sprout) and collect is a significant pointer. This changes in view of the assortment and ecological circumstances (e.g., environment, elevation). For most banana assortments, the ideal reaping time is between 75 to 120 days subsequent to blossoming, contingent upon the developing district.
- **Assortment Contemplations:** Various assortments mature at various times. For instance, Cavendish bananas commonly require 90-110 days from blooming to reap.

Variety Change at Bloom End

- Bloom End Tone: At the bloom end (tip) of the banana, there is many times a slight variety change from green to a light yellow.

- This is an indication of development and a marker that the banana is fit to be gathered.

Strip Tone

Strip Variety Stage: Bananas are commonly gathered while they are as yet green yet completely full grown. The green tone ought to be uniform, with no yellowing aside from slight changes at the bloom end. In the event that the bananas are collected excessively green, they may not age as expected, while over-mature natural product might age excessively fast during transport or capacity.

Size and Weight

- **Finger Size:** Mature bananas arrive at their full finger size, which relies upon the assortment and ecological circumstances. For send out bananas, uniform size is basic, so bananas are generally reaped when the fingers have arrived at a particular length and thickness.
- **Bundle Weight:** A weighty pack can likewise be a sign of development, as the natural product finishes up and puts on weight as it develops.

Market Contemplations

- **Send out versus Nearby Business sectors:** Bananas gathered for neighborhood markets can be collected at a somewhat further developed development stage since the natural product can age en route to showcase. For send out, bananas are reaped prior (around 75-80% development) to guarantee they don't mature excessively fast during transport.
- **Planned Use:** Bananas expected for handling (e.g., chips or banana flour) might be gathered at various phases of development contrasted with those for new utilization.

2. Harvesting techniques (hand-picking mechanical)

Banana gathering requires cautious taking care of to limit harm, as the natural product is sensitive and inclined to swelling. . There are two fundamental reaping methods: hand-picking (manual gathering) and mechanical collecting. Each has its advantages and difficulties, contingent upon the size of activity, work accessibility, and the territory of the estate.

Hand-Picking (Manual Reaping):

Manual reaping is the most widely recognized strategy utilized around the world, particularly in locales where banana manors are little or medium in scale and on lopsided or slanted landscape.

Process:

Cutting the Tail, first Laborers, frequently called "cutters" or "gatherers," utilize sharp blades or cleavers to cut the banana pack from the plant. The tail is sliced neatly to try not to harm the leafy foods plant. Supporting the Bundle, A subsequent specialist, frequently called a "transporter," utilizes a cushioned shoulder saddle or backing stick to get the banana pack as it is sliced and lower it to the ground delicately, abstaining from swelling or effect. The reaped bundles are then moved, frequently on cushioned trucks or transport lines, to a focal assortment or pressing region. Subsequent to gathering the bundle, the excess piece of the banana plant (pseudo stem) is many times chopped down to get ready for the following planting or ratoon crop (the regrowth of the banana plant).

Benefits of Manual Reaping:

- Human laborers can deal with the packs cautiously, limiting harm to fragile natural product.
- Manual reaping is versatile to different landscapes, including bumpy or lopsided fields where machines might battle.
- Laborers can choose just the developed packs, leaving youthful ones on the plant for later collect.

Challenges of Manual Harvesting:

- It requires a ton of physical work, which can be expensive, particularly in huge ranches or districts with work deficiencies.
- Contrasted with mechanical strategies, manual gathering can be more slow.
- There is a gamble of injury to laborers because of the utilization of sharp devices and the need to convey weighty packs.

Mechanical Collecting

Mechanical collecting is more uncommon yet is utilized in some enormous scope banana manors, particularly in regions with generally level landscape and where work costs are high. It includes the utilization of mechanical frameworks to help or completely robotize the collecting system.

- **Cableway Framework:** A famous strategy includes a cableway framework, where banana bundles are collected physically yet shipped precisely. The specialists cut the bundles, which are then joined to a link framework and moved to the pressing region without the requirement for manual conveying. This lessens the actual burden on specialists and paces up transportation.

- **Completely Motorized Frameworks:** In uncommon cases, completely automated frameworks are utilized, where machinesboth cut and gather the banana packs. These frameworks can be more normal in other organic product gathering processes, yet because of bananas' sensitive nature, they are less every now and again utilized here.

Benefits of Mechanical Collecting:

- Mechanical frameworks, for example, cableways, can altogether decrease the time and work expected for moving bananas from the field to the pressing region.
- Cost Reserve funds, in locales with high work costs, mechanical frameworks can decrease the quantity of laborers required and lower work related costs.
- Diminished Actual Strain, via mechanizing transport, mechanical frameworks lessen the actual weight on specialists who might somehow or another convey weighty bundles significant distances.

Challenges of Mechanical Harvesting:

- Completely motorized collecting frameworks risk swelling or harming the natural product because of harsh dealing with, which is a critical issue for a fragile harvest like bananas.
- The establishment of mechanical frameworks, for example, cableways, requires a high beginning interest in gear and foundation.
- Mechanical collecting is commonly restricted to level or delicately slanting regions. In sloping or lopsided landscape, manual collecting is in many cases actually required.
- Motorized frameworks may not be essentially as exact as human specialists in choosing just mature bundles, which could prompt reaping youthful natural product.

Combining Manual and Mechanical Techniques

Numerous cutting edge banana ranches utilize a mix of manual and mechanical methods. For instance, manual reaping is utilized to cut the banana packs, while mechanical frameworks like cableways or transport lines are utilized to move the natural product. This half breed approach advances work while lessening actual strain and expanding proficiency

Summary of Harvesting Techniques:

Method	Advantages	Challenge poor's
Hand-Picking (Manual)	-Precise, minimal fruit damage -Adaptable to terrain	-Labor-intensive -Slower compared to mechanical harvesting
Mechanical	-Faster -Reduced labor costs and physical strain	-Higher risk of damage -Expensive equipment -Limited by terrain
Hybrid(Manual + Mechanical)	-Optimizes labor and efficiency	-Initial investment required for transport systems like cableways.

POST-HARVEST HANDLING

Post-harvest handling of bananas is crucial to maintain their quality, reduce losses, and extend their shelf life.

Harvesting

- **Maturity Stage**: Bananas ought to be gathered when they are full grown yet green. The right development stage guarantees legitimate aging during stockpiling and transport.
- **Harvest Method**: Utilize spotless, sharp apparatuses to abstain from swelling and harm. Laborers ought to deal with the natural products cautiously.

Cleaning

- **Removal of Latex**: Subsequent to cutting, bananas discharge plastic, which should be washed off. Plastic can stain the leafy foods its appearance.
- **Washing**: Bananas are generally cleaned with water to eliminate soil, trash, and plastic stains.

Grading and Sorting

- Bananas are arranged in light of size, weight, and appearance. Harmed, disfigured, or immature bananas are isolated.
- Reviewing arranges bananas for various business sectors (e.g., nearby utilization or commodity).

Packaging

- Utilize proper materials to safeguard bananas from actual harm. For the most part, bananas are pressed in ventilated cardboard boxes or plastic cartons.
- Padding materials like paper or froth are many times utilized between the layers to forestall swelling.

Ripening

- **Controlled Aging:** Ethylene gas is utilized in controlled conditions to consistently mature bananas. Temperature, stickiness, and gas fixation are observed intently.
- **Aging Rooms:** Exceptional rooms are prepared to control maturing conditions, which incorporate temperatures of around 14-18°C and ethylene levels of 100-150 ppm.

Storage and preservation

Proper storage and preservation of bananas are essential to maintaining their quality, extending shelf life, and minimizing post-harvest losses. Since bananas are highly perishable, effective storage methods are critical, especially for large-scale producers and exporters.

Temperature Management:

Bananas are profoundly delicate to temperature, and overseeing stockpiling temperatures is the most basic calculate drawing out their time span of usability.

- **Optimal Storage Temperature:** For green, unripe bananas, the ideal stockpiling temperature is between 13-15°C (55-59°F). This temperature range dials back the aging system while forestalling chilling injury, which can happen assuming that the temperature decreases underneath 13°C.
- **Ripened Bananas:** When bananas are completely aged, they can be put away at somewhat lower temperatures (12-14°C) for brief periods to expand time span of usability.
- **Chilling Injury:** In the event that bananas are presented to temperatures underneath 13°C for expanded periods, they can foster chilling injury, which brings about strip staining, a rubbery surface, and lopsided maturing.

Humidity Control:

- **Relative Humidity**: Bananas ought to be put away in a climate with 85-95% relative dampness to forestall unnecessary dampness misfortune. Assuming that stickiness is excessively low, bananas can lose water, prompting withering and low quality. High moistness keeps up with solidness and keeps the strip from drying out.

- **Avoid Excess Moisture**: While high mugginess is valuable, extreme dampness on the banana skin can prompt contagious development, for example, crown decay, so legitimate ventilation is fundamental.
- **Chilling Injury**: Bananas are defenseless to chilling injury whenever presented to temperatures beneath 12°C, prompting darkening and unfortunate aging.

Controlled Atmosphere Storage (CA)

Controlled climate (CA) stockpiling includes managing the degrees of oxygen, carbon dioxide, and nitrogen in the capacity climate to defer maturing and expand the time span of usability of bananas.

- **Low Oxygen Levels:** Diminishing the oxygen level to 2-5% dials back the breath pace of bananas and postpones aging.
- **Expanded Carbon Dioxide:** Expanding the carbon dioxide fixation to 5-10% stifles the maturing system and diminishes the impacts of ethylene, a characteristic maturing chemical.
- **Nitrogen:** The excess air gases are ordinarily nitrogen, which keeps up with the natural product's solidness.

Ethylene Management

Bananas are climacteric organic products, meaning they produce and are delicate to ethylene, a characteristic chemical that sets off the maturing system.

- **Ethylene Absorption:** Ethylene scroungers or safeguards (like potassium permanganate sachets) can be set away regions to retain ethylene gas, dialing back the maturing system.
- **Ethylene Suppression:** Bananas can be put away with ethylene inhibitors like 1-Methylcyclopropene (1-MCP), which hinders ethylene's activity, subsequently deferring the beginning of maturing.

Short-Term vs. Long-Term Storage

- **Short-Term Storage:** For bananas implied for guaranteed deal or neighborhood markets, transient capacity at somewhat lower temperatures (13-15°C) is adequate. This technique keeps the bananas firm and defers maturing for a couple of days.

- **Long-Term Storage:** For trade markets, long haul stockpiling in refrigerated compartments or controlled environment capacity is utilized to keep up with bananas in their green state for quite some time (up to 3 a month). This is especially significant for bananas that should be moved over significant distances.

Transportation

- Bananas are moved in refrigerated compartments with controlled temperatures to guarantee they don't mature rashly during travel.
- Bundling ought to be enhanced to limit development inside the containers to stay away from actual harm.

Marketing

- Opportune dispersion to the market is fundamental. Legitimate dealing with during this stage guarantees that bananas arrive at shoppers looking great.

4. INNOVATIONS IN POST-HARVEST HANDLING

Developing post-gather the executives for bananas can altogether further develop the time span of usability, quality, and market worth of the produce.

- **Altered Climate Bundling (Guide):** Broadens the timeframe of realistic usability by controlling the oxygen and carbon dioxide levels inside the bundling.
- **Eatable Coatings:** Normal coatings are being created to upgrade banana timeframe of realistic usability and decrease the requirement for plastic bundling.

Smart Storage Systems

- **Controlled Air (CA) Stockpiling:** This includes directing temperature, dampness, and gas focuses away offices to dial back breath and maturing.
- **Cold Chain The board:** Keeping a virus tie from homestead to showcase, where bananas are kept at ideal temperatures, can diminish post-reap misfortunes. Reconciliation of IoT-empowered frameworks can screen continuous temperature and dampness.

Waste Reduction and Value Addition

- **Banana By-products:** Using banana squander (strips, leaves, and so on) for making esteem added items like banana flour, fiber, or biofuels decreases post-gather misfortunes and creates extra income.

- **Compostable Packaging:** Banana plant filaments can be changed into eco-accommodating bundling materials, decreasing plastic waste.

Advanced Developments

- **Block chain for Inventory network Straightforwardness**: Block chain innovation can be incorporated to follow and confirm the excursion of bananas from homestead to buyer, decreasing extortion and guaranteeing quality control.
- **Artificial intelligence and AI:** Prescient examination can conjecture aging stages, post-gather misfortunes, and advance coordinated operations in light of information from past seasons.

Sun based fueled Drying out and Handling

- **Sun based Drying Frameworks:** Creating effective sun oriented fueled drying frameworks can transform surplus bananas into dried banana items, broadening their timeframe of realistic usability and opening up new market prospects.
- **Handling Focuses close to Homesteads:** Laying out nearby handling units for making items like banana chips, flour, or puree can decrease post-collect misfortunes and transportation costs.

5. VALUE ADDITION

Esteem expansion in banana cultivating includes changing crude bananas into items that offer higher monetary returns. It diminishes post-gather misfortunes as well as sets out more market open doors.

- ✓ Banana Fiber Extraction
- ✓ Banana Vinegar
- ✓ Dried Banana or Banana Powder
- ✓ Banana-based Ice cream parlor
- ✓ Banana-based Tidbits
- ✓ Banana Flour Noodles and Pasta
- ✓ Biogas from Banana Squander
- ✓ Banana Frozen yogurt

6. GOVERNMENT INITIATIVES AND POLICIES

- ✓ National Horticulture Mission (NHM)
- ✓ Mission for Integrated Development of Horticulture (MIDH)
- ✓ Rashtriya Krishi Vikas Yojana (RKVY)
- ✓ National Agriculture Market (eNAM)
- ✓ Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)
- ✓ Agri-Export Policy
- ✓ Kisan Credit Card (KCC) Scheme
- ✓ Banana Producer Organizations (FPOs

Conclusion

Banana creation holds gigantic importance in India's farming economy, especially in Tamil Nadu, a main banana-delivering state. Notwithstanding, a critical level of the reap is lost because of lacking post-collect administration, bringing about monetary misfortunes and decreased food accessibility. To relieve these issues, taking on extensive post-reap the executives systems is fundamental. Legitimate dealing with works on, including ideal gathering at the right development stage, cautious taking care of, and fitting transportation, can extraordinarily diminish misfortunes and keep up with the natural product's quality. Strategies like controlled maturing, stockpiling with dampness and temperature control, and advancements.Tamil Nadu's banana ranchers, with the assistance of government drives like the Public Agriculture Mission (NHM) and the Rashtriya Krishi Vikas Yojana (RKVY), can possibly diminish post-reap misfortunes and further develop market access through improved esteem added items like banana flour, chips, and filaments. By zeroing in on maintainability, innovation driven arrangements, and worth expansion, the state can lead in both homegrown utilization and worldwide products. Eventually, further developing post-gather rehearses not just guarantees that the nature of bananas is kept up with yet additionally improves financial returns, upholds food security, and cultivates reasonable farming development.

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THERI LAND (RED SAND DUNE) MANAGEMENT BY AMENDMENTS FOR CULTIVATION OF WATERMELON

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Introduction

Most of us may not know the small desert situated in southern districts of Tamil Nadu. It consists of red sand dunes and is confined to Tirunelveli and Thoothukudi district. The red dunes are called ***Theri*** in Tamil. The iron-rich heavy minerals like ilmenite, magnetite, garnet, hypersthene and rutile present in the soil had undergone leaching by surface water and were then oxidised because of the favourable semi-arid climatic conditions. The fine materials with light weight are picked up, suspended in the air and carried away. These processes of erosion, transport and deposit of sediments that are caused by wind at or near the surface of the earth, are called *"Aeolian processe"s.*

Location of *Theri* land

The *Theri* lands (red sand dunes) are one of the marginal wastelands in Tirunelveli and Thoothukudi districts of Tamil Nadu. These *Theries* are located (77^{o} 49' 44" to 78^{o} 28' 22" E and from 8^{o} 15'13" to 9^{o} 11' 0" N), to an extent of around 20,000 ha (Jawahar *et al*., 1999). The soils have low nutrient status, low water holding capacity, low organic carbon content and are susceptible to high wind erosion. The sand dune ecosystem formed in *isomegathermic* and *ustic* regime from geogenic sand deposit under a semi arid climate. As the soil texture is sandy, it is subjected to severe wind erosion and characterized with poor nutrient status. Water holding capacity of this soil very low owing to the very low clay content, poor organic carbon content and single grain structure (Manikandan and Subramanian, 2010). The mean annual rainfall of the study area is between 610 to 700 mm.

Eco system of *Theri* land

These wastelands (*Theries*) have stabilized and unstabilised sand dunes. The sparse natural vegetations are mainly *Borassus flabellifer*, *Accacia spp.* and *Dodonea viscosa along* with cultivated cashew trees. In limited area where ground water potential is high, *Musa spp.*, *Moringa spp.*, *Cocus mucifera* and *Arachis hypogea* are grown.

Characteristics of *Theri* soil

Soil parameters	**Values**
Texture	Sandy
Clay (per cent)	4.6
Silt (per cent)	5.5
Fine sand (per cent)	86.3
Coarse sand (per cent)	3.5
Bulk density (Mg m^{-3})	1.58
Particle density (Mg m^{-3})	2.63
Organic carbon (per cent)	0.12
CEC (c mol (p^{+}) kg^{-1})	11.3
pH	6.6
EC (dS m^{-1})	0.13
Available nitrogen (kg ha^{-1})	93.7
Available phosphorus (kg ha	8.2
Available potassium (kg ha	88.5

(Paramasivan *et al.*, 2023)

Organic amendments for *Theri* soil

In sandy soils, organic amendments like, Tank silt, FYM, Composted coir pith (CCP) *etc.* increase the water and nutrient holding capacity. A soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. The goal is to provide a better environment for roots. Organic amendments increase soil organic matter content and offer many benefits. Over time, organic matter improves soil aeration, water infiltration, and both water- and nutrient-holding capacity. Many organic amendments contain plant nutrients and act as organic fertilizers. Organic matter also is an important energy source for bacteria, fungi and earthworms that live in the soil.

Tank silt

Removal of tank silt and its application on agricultural lands is a traditional activity done by farmers for sustainability and productivity. Application of tank silt as an amendments to the sandy soil is economically viable for improving the soil physical and chemical properties of soil.

Properties of tank silt

Soil parameters	Values
Texture	Clay
Clay (per cent)	71.8
Silt (per cent)	19.3
Fine sand (per cent)	6.8
Coarse sand (per cent)	1.4
Organic carbon (per cent)	1.6
pH	7.4
EC (dS m^{-1})	0.22
Available nitrogen (kg ha^{-1})	360
Available phosphorus (kg ha^{-1})	28
Available potassium (kg ha^{-1})	210

Experiment conducted

The experiment was laid out in Factorial Randomized Block Design (FRBD) with six treatments and three replications. Factor as three organic amendments viz., tank silt @ 100 t ha^{-1}, composted coir pith @ 12.5 t ha^{-1} and farm yard manure @ 20 t ha^{-1} were applied as basal doses before sowing. The treatments were T_1- 75 % recommended dose of fertilizers (RDF) (150:75:75 kg of NPK ha^{-1}) through soil application; T_2- 100 % recommended dose of fertilizers (RDF) (200:100:100 kg of NPK ha^{-1}) through soil application; T_3- 75 % recommended dose of fertilizers (RDF) (150:75:75 kg of NPK ha^{-1}) through fertigation at 7 days interval; T_4- 75 % recommended dose of fertilizers (RDF) (150:75:75 kg of NPK ha^{-1}) through fertigation at 15 days interval; T_5- 100 % recommended dose of fertilizers (RDF) (200:100:100 kg of NPK ha^{-1}) through fertigation at 7 days interval; T_6- 100 % recommended dose of fertilizers (RDF) (200:100:100 kg of NPK ha^{-1}) through fertigation at 15 days interval.

Salient findings from the research

Combined effect of amendment and nutrients on yield of watermelon, soil physico-chemical properties and fertility status of soil

The combined of amendments and nutrients played an important role in increasing the production of watermelon. The application of tank silt @ 100 t ha^{-1} along with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval (A1N5) registered more number of branches (10.67), longer vine (362 cm), maximum number of fruits $plant^{-1}$ (2.57), heavy weight of fruit (5.27 kg), maximum fruit yield (68.77 t/ha), maximum content of total soluble solid (10.94%) and ascorbic acid (8.08 mg $100g^{-1}$).

Physico-chemical properties

The interaction effect was significant for all physic-chemical properties of the *theri* land. The least values of particle density and bulk density (2.45 and 1.31 Mg m^{-3}), highest value of per cent pore space (48.33%), increased pH (6.58), EC (0.35 dSm^{-1}) and organic carbon content (0.52%) were also registered for the same treatment by the application of tank silt @ 100 t ha^{-1} along with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval (A1N5).

Nutrient uptake

The combination of amendments and fertilizers played major role in increasing the nutrient uptake of watermelon. The treatment applied with tank silt @ 100 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval (A1N5) registered the maximum uptake of N and K (41.51 and 31.94 kg ha^{-1}). The maximum P uptake (4.27 kg ha^{-1}) was registered for the treatment applied with composted coir pith @ 12.5 t ha^{-1} with 100 per cent NPK through fertigation at 7 days interval (A2N5).

Fertility status

The highest organic carbon (0.52 %), available N, P and K (253.47, 16.40 and 218.40 kg ha^{-1}, respectively) were obtained from the treatment applied with tank silt @ 100 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval (A1N5).

This result is supported by the earlier findings of Sajitha (2016), Shyamaa *et al.,* 2009, Annadurai *et al.,* (2005) and Kadam *et al.,* (2009). They clearly suggested that combined application of amendments with nutrients maintain in increasing crop yield. The increase in the fruit yield might be due to the application of organic amendments in combination with inorganic fertilizers. There is a need to use organic and chemical fertilizers in combination with drip fertigation so as to increase crop productivity.

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ENHANCING AND MAINTAINING SEED QUALITY OF WHEAT

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Abstract

Seed quality is a crucial factor in wheat production, directly influencing germination rates, crop establishment, and yield. High-quality seeds ensure healthy crop growth, resilience against diseases, and efficient resource utilization. This review explores methods for enhancing and maintaining wheat seed quality, including genetic selection, seed treatment, storage conditions, and quality assessment techniques. Case studies and research findings are referenced to illustrate the effectiveness of these practices.

Key words: Seed quality, Wheat, Production

Introduction

Wheat is one of the world's most vital crops, providing a major source of food and nutrition for a significant portion of the global population. The success of wheat cultivation is heavily dependent on the quality of the seeds used. High-quality seeds lead to better germination, robust crop establishment, and higher yields, contributing directly to food security and economic stability in wheat-producing regions. Conversely, poor seed quality can result in reduced plant vigor, susceptibility to diseases, and lower yields, which can have cascading negative effects on agricultural productivity and profitability. The quality of wheat seeds is influenced by various factors, including genetics, environmental conditions during seed development, and post-harvest handling. Enhancing and maintaining seed quality involves implementing strategies across these factors to ensure that seeds retain their viability, vigor, and potential to produce healthy plants.

This includes selecting high-quality genetic material, employing effective seed treatments, optimizing storage conditions, and conducting rigorous quality assessments. In recent years, advances in agricultural science and technology have provided new methods for improving seed quality. These advancements range from precision breeding techniques to innovative seed treatments and storage solutions. By adopting these practices, farmers and seed producers can significantly enhance the quality of wheat seeds, leading to improved crop performance, greater resilience against environmental stresses, and increased overall productivity.

This review explores the various strategies and techniques available for enhancing and maintaining wheat seed quality, discussing their effectiveness and implications for sustainable wheat production. Through understanding and implementing these approaches, stakeholders in the wheat industry can ensure the consistent production of high-quality seeds, which is fundamental to achieving optimal yields and supporting global food systems.

Factors Affecting Wheat Seed Quality

1. **Genetic Selection and Breeding**
   - **Varietal Selection**: Choosing the right wheat variety is the first step in ensuring seed quality. Varieties with genetic resistance to diseases, pests, and environmental stresses tend to produce higher-quality seeds .
   - **Hybrid Breeding**: Hybrid wheat breeding can enhance seed quality by combining desirable traits such as drought tolerance, disease resistance, and high yield potential. This results in seeds that are more vigorous and adaptable to different growing conditions .
2. **Seed Treatment**
   - **Chemical Treatments**: Treating seeds with fungicides, insecticides, and growth regulators can protect them from pathogens and pests during the initial growth stages, ensuring better germination and establishment .
   - **Biological Treatments**: Using beneficial microbes and biofertilizers enhances seed quality by promoting nutrient uptake, improving stress tolerance, and reducing the reliance on chemical inputs .
   - **Physical Treatments**: Techniques like priming (pre-soaking seeds in water or solutions) can enhance seed germination and early seedling growth by improving metabolic activities.

3. **Storage Conditions**
   - **Temperature and Humidity Control**: Maintaining optimal storage conditions is crucial for preserving seed viability and vigor. Low temperatures and controlled humidity levels reduce the risk of seed deterioration and fungal contamination.
   - **Packaging**: Using moisture-proof and airtight packaging materials prevents seed exposure to environmental fluctuations, maintaining their quality over time.
4. **Quality Assessment and Certification**
   - **Germination Testing**: Regular germination tests provide information on the seed's ability to sprout and grow under optimal conditions, ensuring only high-quality seeds are used for planting.
   - **Vigor Testing**: Seed vigor tests assess the potential for rapid and uniform emergence under various conditions, providing an indication of the seed's overall health and quality.
   - **Seed Certification**: Certified seed programs ensure that seeds meet specific standards for purity, germination rate, and freedom from contaminants, giving farmers confidence in seed quality.

Enhancing Seed Quality

1. **Genetic Improvement**
   - **Molecular Breeding**: Marker-assisted selection (MAS) and genetic engineering can enhance desirable traits in wheat, such as disease resistance and abiotic stress tolerance, leading to the production of high-quality seeds.
   - **Transgenic Approaches**: Developing transgenic wheat varieties with improved traits such as herbicide tolerance and enhanced nutritional content can result in better seed quality and higher crop performance.
2. **Improving Seed Treatments**
   - **Nano-coating**: Applying nano-particles to seeds can improve their germination and growth by enhancing water and nutrient uptake, providing a protective barrier against pathogens.
   - **Organic Seed Treatments**: Utilizing organic compounds like neem oil and compost teas as seed treatments offers an eco-friendly alternative to chemical treatments, enhancing seed quality without harming the environment .

Maintaining Seed Quality

1. **Optimal Harvesting and Post-Harvest Handling**
   - **Timely Harvesting**: Harvesting wheat at the right time, when seeds have reached physiological maturity, ensures maximum viability and vigor .
   - **Proper Threshing and Cleaning**: Minimizing mechanical damage during threshing and cleaning processes helps maintain seed integrity and reduces the risk of contamination.
2. **Advanced Storage Techniques**
   - **Controlled Atmosphere Storage**: Using controlled atmosphere storage (CAS) techniques, which regulate oxygen and carbon dioxide levels, can extend seed viability by slowing down metabolic activities.
   - **Seed Banks and Cryopreservation**: Long-term storage in seed banks and cryopreservation can maintain seed quality for extended periods, providing a valuable resource for future breeding programs and genetic diversity conservation.

Conclusion

Enhancing and maintaining the quality of wheat seeds is essential for achieving high crop productivity and sustainability. By employing strategies such as genetic selection, advanced seed treatments, optimal storage conditions, and rigorous quality assessment, farmers and seed producers can ensure the availability of high-quality seeds. Continued research and development in these areas will further improve wheat production systems, contributing to global food security.

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MANAGEMENT OF FRUIT CRACKING IN POMEGRANATE

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Introduction

The juicy pomegranate, a fruit from the Punicaceae family, is a major player in the world of commerce. India leads the pack in both the total area cultivated and the fruit produced! With over 2.7 lakh hectares dedicated to pomegranate cultivatioin and a whopping 30.88 lakh tonnes production, India boasts an impressive average yield of 6.9 tonnes per hectare.Nutritive value in 100 g arils provides 72 kcal of energy, 1.0 g protein, 16.6 g carbohydrate, 379 mg potassium, 13 mg calcium, 12 mg magnesium, 0.7 mg iron, 0.17 mg copper, 0.3 mg niacin and 7 mg vitamin C. Pomegranate is immense of medicinal uses which is a cure for diarrhoea, diabetes, blood pressure, leprosy, hemorrhages, bronchitis, dyspepsia and inflammation. Anti-allergic, anti-microbial and anti-carcinogenic. Wild pomegranate fruit is highly acidic containing citric, malic, oxalic, succinic and tartaric acids. Dried aril is called anardana which is used as souring agent in Indian cusine. The fruit is a luscious berry with several seeds within, each encasedina, juicy, mushy aril.

The outer epidermal cells of the seed, which greatly lengthen in a radial direction, are the source from which the arils grow. The pomegranates are native to central Asia, they are highly adaptable to a variety of climates and soil types.

Fruit splitting, also known as cracking, is a big problem for pomegranate growers. It can significantly reduce the harvest and make the fruit less appealing to buyers. The fruit loses its market value and frequently turns into an unsafe food for humans to eat (Panwar *et al.,* 1994). Fruit cracking and sun scorching during the fruit's growth and development put a serious threat to the pomegranate industry, significantly reducing its commercial value and economic yield. Although splitting and cracking have been explained in a variety of ways, the term "cracking" is clearly associated with most fruits, including avocado, citrus, tomato, pomegranate, litchi, apple, sweet cherry, grape, plum, and pine. When a ripe fruit cracks, certain bacteria or fungus may infiltrate it. In Pomegranate fruit cracking is a common issue across all cultivating regions and various types throughout the world, while the severity of the issue varies according to weather, genetics, variety, fruit development, and cultural customs (Saad *et al.*, 1988).

Extent of Losses

Yield loss due to fruit cracking can exceed 65%, with cracked fruits being sweeter, having poor keeping quality, unfit for shipment, and prone to rotting (Malhotra *et al.,* 1983). This issue varies among varieties and is worse in harsh climates, with losses up to 65%–75% in arid regions (Prasad *et al.,* 2003). Singh *et al*. (2014) reported variability in fruit cracking from 18.3% to 62.6% in arid regions. Pant (1976) found cracking rates of 63% in spring, 34% in winter, and 9.5% in the rainy season, with variations in rind thickness, fruit size, aril size, juice content, and total soluble solids. Economic losses range from 10% to 40%, sometimes reaching 70% (Pal *et al.,* 2017). Omima *et al.* (2014) noted that cracking reduces fruit marketing value by about 50%.

Factors for Fruit Cracking

Fruit cracking may be caused by low relative air humidity (RH), excessive evapo transpiration, water imbalance, and abrupt day-to-night temperature fluctuations during fruit development (Abd and Rahman, 2010). Additionally, inappropriate irrigation practices, environmental variables, and dietary deficiencies—particularly in boron, calcium, zinc, and potash—have been linked to it (Saei *et al.*, 2014). Causes associated with fruit cracking can be improper irrigation, environmental factors, and nutritional deficiency, especially boron, calcium, and potash. Besides, it is also reported to be associated with high evapo-transpiration, low humidity, water imbalance, and sharp temperature fluctuation in day and night during fruit growth and development. The cracking is more evident when the fruits are at maturity stage. No single factor can be advocated as efficient enough in controlling fruit cracking.

A) Soil moisture: One of the main causes of fruit cracking is soil moisture. Fruit cracking results from moisture stress followed by an abrupt increase in soil moisture content (by irrigation or rainfall)

B) Relative humidity: Because low humidity increases fruit surface evaporation, it intensifies cracking.

C) Rainfall: When fruit peels come into touch with rainwater or mist, they break down more quickly because the peel absorbs the water from the surface micropores, which increases internal turgor pressure and causes macrocracks on the fruit's surface.

D) Temperature: Variability between daytime and evening temperatures.

E) Hormonal factors: Fruit cracking is regulated in part by auxins, cytokinins, and ABA. Less auxin was present in the skin and seeds of the fractured Litchi fruits.

F) Nutritional status: It has been proposed that variations in the susceptibility of fruits on various trees, or even on the same tree, to cracking can be explained by the nutritional state of the tree and the fruit. Cracking in various fruits is linked to deficiencies in zinc, calcium, boron, and sulphur.

G) Chemical sprays: Fruit development has been seen to be distorted and cracked by lead arsenate and phosdrin spray. Cracking is brought on by herbicides and surfactants like Tween-20 that increases water absorption.

Management of Fruit Cracking

Arid and semi-arid regions receiving low annual rainfall below 1000 mm (preferable around 560 mm) with a long, hot and dry summer and mild winter are suitable for quality fruit production.To reduce early pomegranate fruit breaking, Singh *et al.* (1990) proposed a variety of cultural techniques, such as weekly watering, mulching with dried grass or farmyard manure, spraying with 0.005 or 0.002% boric acid, 1% KNO_3, or 1% $MgSO_4$. In comparison to the control treatment, Hegazi *et al.* (2014) found that fruit cracking was reduced to the lowest percentage in Manfaloty and Wonderfull pomegranate varieties when fruit bagging was applied, followed by 5% kaolin and spraying with GA_3 and $CaCl_2$. Spraying liquid paraffin at 1 % concentration at 15 days interval twice during June reduces fruit cracking.

Singh *et al.* (2017) reported that foliar application of borax (0.4%), zinc sulfate (0.5%), and kaolin (4%) with mulching of tree basin (black polythene sheet 150 µ) is more effective in minimizing fruit cracking rather than sprays alone. When under water stress, pomegranate fruit is applied foliar spraying with 3% and 1% calcium-boron, 6% kaolin, and 2 ml of humic acid. Fruit cracking percentage was positively impacted and fruit quality was enhanced by preharvest treatment of various growth regulators and mineral nutrients, such as Paclobutrazol, GA_3, NAA, $CaCl_2$, boric acid, and $ZnSO_4$, at the early stages of fruit growth in pomegranate trees. Different bagging techniques on off-season longan fruit revealed that the incidence of cracking was decreased by using black adhesive-bonded fabric bags with less than 10% light transmittance and white adhesive-bonded fabric bags with around 70% light transmittance. Regular irrigation to maintain soil moisture at desired level, spraying of calcium compounds or GA_3 at 120 ppm on young pomegranate fruits helps to minimize the fruit cracking. As cracking is a complex issue, it was observed during various studies correct nutrition with calcium, magnesium, boron, and zinc were very effective in reducing fruit splitting in various pomegranate cultivars.

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NUTRI GARDENS AS A TOOL FOR WOMEN EMPOWERMENT AND LIVELIHOOD GENERATION

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Abstract

Nutri Gardens serve as a vital tool for women's empowerment and livelihood generation by providing opportunities for economic freedom, enhancing food security, and nurturing skill development. These small-scale gardens enable women to grow nutritious food for their families while generating income through the sale of surplus produce. By contributing in Nutri Garden enterprises, women not only gain valuable agricultural skills but also build social networks that reinforce community ties. Furthermore, these gardens promote sustainable practices and environmental stewardship, allowing women to become active go-betweens of change within their communities. Overall, Nutri Gardens contribute significantly to improving the quality of life for women and their families while fostering resilience and empowerment in the face of socio-economic challenges.

Key words: Nutri Gardens, Women, Economic freedom, Livelihood

Introduction

The concept of Nutri Gardens, small-scale, nutrition-focused vegetable gardens has gained traction in recent years for its potential to promote food security and enhance health. However, the impact of Nutri Gardens goes beyond just providing nutritious food. In rural and urban communities alike, these gardens have emerged as powerful tools for women empowerment and livelihood generation. By equipping women with the skills, resources, and opportunities to grow their own food, Nutri Gardens are creating pathways for financial independence, improved health, and social status. This article explores how Nutri Gardens are contributing to the empowerment of women and their role in creating sustainable livelihood options.

Empowerment is a multifaceted concept that involves economic, social, and psychological dimensions. For women, empowerment means having access to resources, decision-making power, and opportunities to improve their quality of life. Nutri Gardens serve as an effective entry point for this transformation by providing women with a platform to engage in productive agricultural activities, even in small spaces.

Financial Empowerment through Revenue Opportunities

One of the primary ways Nutri Gardens empower women is by offering avenues for income generation. Many women, especially in rural areas, have limited access to formal employment opportunities. Nutri Gardens allow them to generate additional household income through the sale of surplus vegetables, herbs, and fruits grown in these gardens. The produce can be sold in local markets or used for value-added products like pickles, jams, and organic teas, thereby creating a small-scale business model. The income generated from these activities enables women to contribute financially to their households, which can shift the traditional dynamics within the family. With financial self-sufficiency, women can invest in their children's education, healthcare, and other family needs, improving their overall economic well-being.

Improving Food Access and Nutritional Well-being

Women play a central role in ensuring the nutrition and health of their families. By establishing Nutri Gardens, women gain control over the food supply, ensuring that their families have consistent access to fresh and nutritious produce. This is especially critical in regions where malnutrition and food insecurity are predominant. With improved food security, women can better achieve household nutrition, leading to healthier families and communities.Furthermore, through training and awareness programs associated with Nutri Gardens, women become educated about the nutritional value of various crops and the importance of a balanced diet. This knowledge empowers them to make informed decisions about their family's dietary habits, promoting better health outcomes.

Building Skills and Developing Capabilities

Setting up and maintaining a Nutri Garden involves various skills, such as organic farming techniques, composting, water management, pest control, and crop planning. Many organizations and government initiatives offer training programs specifically for women to build their capacity in these areas. As women acquire these skills, they not only become proficient in gardening but also gain confidence and a sense of accomplishment. These skills are transferrable and can be used to expand into other agricultural or entrepreneurial activities.

Skill development also increases women's employability in the agricultural sector, which can lead to more stable livelihood opportunities. In some cases, women's groups have formed cooperatives to manage larger-scale Nutri Gardens or nurseries, enhancing their ability to market their produce collectively and negotiate better prices.

Fostering Social Connections and Strengthening Community Ties

Nutri Gardens have the potential to build strong social networks among women, especially when they are implemented as community projects. Women come together to share resources, knowledge, and labor, nurturing a spirit of cooperation and reciprocal support. This creates a sense of community ownership and pride. It also provides women with a platform to discuss other issues that affect them, such as education, health, and rights, further enhancing their social empowerment.

Moreover, in many cultures, women's participation in community activities is limited due to social norms. Nutri Gardens offer an suitable and culturally sensitive space for women to gather, interact, and work together, thereby promoting their social inclusion and visibility within the community.

Promoting Environmental Responsibility and Sustainable Practices

Many women involved in Nutri Gardens are adopting sustainable practices such as organic farming, water conservation, and waste recycling. By promoting eco-friendly gardening techniques, women become agents of environmental stewardship in their communities. This aspect of empowerment extends beyond individual and family benefits, as women play a critical role in promoting sustainable agriculture and environmental health at the community level.

Furthermore, engaging women in environmentally sustainable practices helps them acquire a unique set of skills that can be utilized in various agricultural ventures, making them pioneers of change in the way local food systems operate.

Challenges and pathways ahead

While Nutri Gardens present a promising tool for women empowerment and livelihood generation, several challenges remain. Limited access to land, lack of initial capital for setting up gardens, and inadequate training are common barriers faced by women. Additionally, in some communities, social norms and gender biases restrict women's participation in economic activities, making it difficult for them to fully benefit from such initiatives.

To overcome these challenges, supportive policies and interventions are needed. Governments, non-governmental organizations, and local communities can collaborate to provide women with access to land, gardening inputs, and ongoing technical support. Microfinance and credit facilities can be introduced to help women invest in setting up and expanding Nutri Gardens. Establishing women's self-help groups and cooperatives can further amplify their impact by enhancing collective bargaining power and market access.

Conclusion

Nutri Gardens are more than just a source of fresh vegetables and herbs—they are powerful tools for transforming the lives of women. By providing opportunities for income generation, enhancing food security, developing skills, and fostering social networks, Nutri Gardens contribute to the economic and social empowerment of women. With the right support and resources, Nutri Gardens can pave the way for sustainable livelihoods, improved health outcomes, and stronger communities, ultimately leading to a more equitable and resilient society. Investing in Nutri Gardens is not just an investment in food and nutrition; it is an investment in the empowerment of women and the future of their families and communities.

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BIO-OILS: A SUSTAINABLE ALTERNATIVE TO PETROLEUM FUELS

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Abstract

Bio-oil, a promising alternative to crude oil, can be produced from biomass using flash pyrolysis and hydrothermal liquefaction. Despite growing interest due to rising fuel costs, challenges such as high production costs, low yield, and poor quality persist. This review focuses on the processes involved in bio-oil production, including feedstock characteristics, reactor types, and upgrading methods. Key factors affecting bio-oil yield, such as particle size and thermal conditions, are discussed, along with upgrading techniques like hydrodeoxygenation and catalytic cracking. This paper serves as a resource for researchers in alternative fuels.

Keywords: Bio-oil, Biomass, Pyrolysis, Hydrothermal liquefaction, Upgrading.

Introduction

The global energy crisis of the 1970s prompted a shift towards alternative fuels, with biomass emerging as a sustainable source. Unlike fossil fuels, biomass maintains a closed carbon cycle. Diesel engines, prevalent in transportation and agriculture, consume significantly more diesel than petrol in India. Biomass, derived from plants through photosynthesis, includes wood, agricultural wastes, and other organic materials. Thermochemical conversion methods, particularly pyrolysis, are effective for producing bio-oils, which can replace petroleum fuels.

2. TYPES OF REACTORS Pyrolysis can be categorized into fast and slow processes, each employing various reactors:

Fast Pyrolysis: Involves rapid thermal decomposition.

Heinze-type Reactor: Studies on cotton stalk showed yield variations with temperature and particle size.

Bubbling Fluidized Bed: Japanese larch pyrolysis yielded variable activation energies.

Fluidized Bed: Optimal conditions for cotton stalk yielded 55% bio-oil at 510 ºC.

Fixed Bed: Potato skin pyrolysis yielded 27.11% bio-oil in a nitrogen atmosphere.

Slow Pyrolysis: Involves longer reaction times.

Tubular Reactor: Highest liquid yield from rapeseed stalk at 650 ºC and a heating rate of 30 ºC/min.

Fixed Bed: Aquatic microalgae showed potential for biofuel production.

Microwave: Palm kernel and wood chips yielded bio-oils without carcinogenic compounds.

1. **PROCESSES FOR CONVERSION**

Biomass can be converted to bio-oil through flash pyrolysis and hydrothermal liquefaction. Flash pyrolysis quickly decomposes organic materials, producing bio-oil, char, and gas. Hydrothermal liquefaction operates under elevated pressure and temperature, producing bio-crude and various byproducts. Both processes, while simple and cost-effective, generate a range of products, including char. Research indicates that conditions such as substrate type and reaction parameters significantly influence yields.

Bio-oils, derived from biomass through various processes such as pyrolysis and hydrothermal liquefaction, present a promising alternative to conventional petroleum-based fuels. They offer renewable energy solutions and serve as feedstocks for a variety of chemical products.

Cellulose $\rightarrow$ Aqueous Product $\xrightarrow{NikelAlkali}$ Gases $\left(4H_2 + CO_2 \xrightarrow{NI} CH_4 + 2H_2O\right)$

Cellulose $\rightarrow$ Oil $\rightarrow$ Char + Gases

$\uparrow$ Inhibit

Alkali

Fig. 1. Reaction path way for the hydrothermal liquefaction of cellulose.

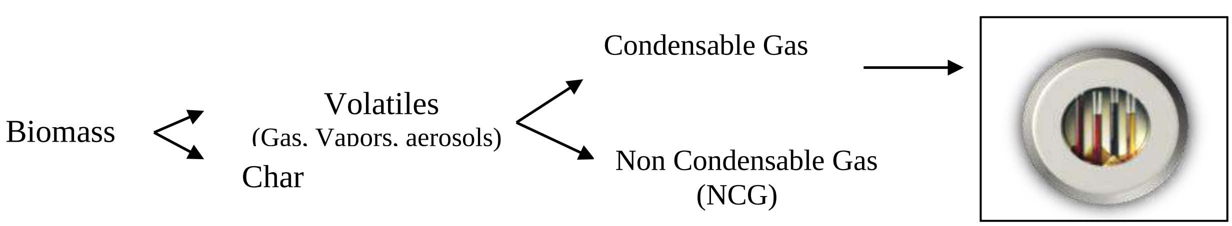

Fig. 2. Reaction path way for the flash pyrolysis process of Biomass.

3. Properties of Bio-oils

Bio-oils are typically dark brown, free-flowing liquids, characterized by their complex mixture of organic compounds, including acids, alcohols, aldehydes, esters, ketones, phenols, and lignin-derived oligomers. Their physical and chemical properties significantly differ from those of petroleum-derived oils, primarily due to their distinct chemical composition.

Key properties of bio-oils from various sources include:

Bio-oil from Wood Pyrolysis:

Moisture Content: 15–30%

pH: 2.5

Specific Gravity: 1.2

Elemental Composition: C (54-58%), H (5.5-7.0%), O (35-40%), N (0-0.2%)

Ash Content: 0-0.2%

Higher Heating Value (HHV): 16-19 MJ/kg

Viscosity (at 50°C): 40-100 cP

Solids: 0.2-1.0%

Distillation Residue: Up to 50%

Bio-oil from Heavy Petroleum Fuel:

Moisture Content: 0.1%

Specific Gravity: 0.94

Elemental Composition: C (85%), H (11%), O (1.0%), N (0.3%)

Ash Content: 0.1%

HHV: 40 MJ/kg

Viscosity (at 50°C): 180 cP

Solids: 1.0%

Distillation Residue: Up to 1.0%

Despite their potential, bio-oils exhibit undesirable properties for fuel applications, including high water content, viscosity, ash content, low heating value, instability, and corrosiveness. Consequently, upgrading bio-oils is essential to improve their suitability as liquid fuels.

4. Uses of Bio-oils

As a renewable energy source, bio-oils can be stored and transported easily. Their applications include:

Industrial Uses:

Combustion Fuel: Utilized in boilers, furnaces, and engines for heat generation and power production.

Transportation Fuel: Can serve as a substitute for diesel after appropriate upgrading.

Chemical Production: Acts as a raw material for adhesives, phenol-formaldehyde resins, and various specialty chemicals.

Food Industry: Employed for producing liquid smoke and wood flavors.

Biotechnology: Potential for manufacturing anhydro sugars like levoglucosan, useful in pharmaceuticals and biodegradable polymers.

5. Upgrading of Bio-oil

The quality of bio-oils is often inferior to that of petroleum fuels, necessitating various upgrading techniques to enhance their properties.

5.1 Hydrotreating

Hydrotreating is a hydrogenation process that improves bio-oil quality by removing oxygen while maintaining the boiling range. Key aspects include:

Conditions: Mild, with catalysts such as CoMo/Al2O3 and NiMo/Al2O3.

Drawbacks: Produces char, coke, and tar, leading to catalyst deactivation and reactor clogging.

5.2 Hydro-cracking

Hydro-cracking employs high temperatures and pressures, utilizing dual-function catalysts to facilitate cracking and hydrogenation. Key points include:

Conditions: Requires severe conditions (≥350°C, 100-2000 psi).

Advantages: Effective in producing light products, but can lead to high rates of cracking, resulting in the degradation of bio-oil to lighter gases and carbon.

Yield: Studies show oil yields ranging from 14-23 wt%, with significant carbon formation affecting overall efficiency.

Conclusion

The review highlights advancements in bio-oil production technologies and identifies ongoing challenges, such as improving reactor reliability and demonstrating bio-oil applications in energy generation. Future research should focus on maximizing oil yield and developing technologies for chemical and biofuel production from pyrolysis oils. Bio-oils represent a viable renewable energy source with diverse applications. However, their inherent properties necessitate significant upgrading to enhance fuel quality and expand their usability in various industries. Continued research and development in upgrading technologies will be critical for the effective utilization of bio-oils as sustainable energy solutions.

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HARNESSING THE AROMATIC ELEGANCE: EXPLORING THE ESSENCE OF KHUS PLANTS

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Introduction

Nestled in the eastern part of Bihar, the Koshi region boasts a tapestry of fertile plains, meandering rivers, and lush greenery. Amidst this picturesque landscape thrives the humble yet extraordinary Khus plant (*Vetiveria zizanioides*), revered for its myriad benefits and cultural significance. In this comprehensive article, we embark on a journey to uncover the multifaceted uses and advantages of Khus in the Koshi region, exploring its therapeutic, agricultural, ecological, and socio-economic contributions.

History and Origin:

Khus, native to India, has a rich historical significance deeply rooted in traditional practices and cultural heritage. Historically, its fragrant roots were used in perfumery and aromatherapy, dating back to ancient civilizations like India and Egypt. The word "Vetiver" is derived from the Tamil word "Vettiveru," meaning "root that is dug up." Its botanical name, *Vetiveria zizanioides*, reflects its classification within the Poaceae family.

Cultivation:

Khus plants thrive in tropical and subtropical regions, particularly in moist and warm climates. They are well-suited for cultivation in areas with sandy or loamy soil, as they have a deep and extensive root system that aids in soil erosion control. The cultivation process involves planting the root segments or slips in prepared soil beds, followed by regular watering and maintenance. Khus plants are known for their resilience and ability to grow in adverse conditions, making them a sustainable option for soil conservation and land reclamation projects.

Characteristics and Aroma:

One of the most distinctive features of Khus plants is their aromatic roots, which emit a sweet, earthy scent. This aroma is attributed to the presence of essential oils, primarily vetiverol and vetiverone, found in the roots. The fragrance of Khus is often described as calming and grounding, making it a popular choice in aromatherapy and perfumery. Additionally, the dense foliage of Khus plants provides shade and shelter to the surrounding ecosystem, promoting biodiversity and ecological balance.

Uses and Applications:

The versatility of Khus plants extends beyond their aromatic properties, encompassing a wide range of practical applications:

Cultural Significance and Traditional Uses:

Khus, deeply ingrained in the cultural heritage of the Koshi region, holds a special place in the hearts and traditions of its inhabitants. For centuries, this aromatic plant has been an integral part of religious ceremonies, festive celebrations, and daily rituals, symbolizing purity, prosperity, and spiritual renewal. The earthy fragrance of Khus permeates the air during auspicious occasions, invoking a sense of tranquility and reverence among the locals.

In addition to its cultural significance, Khus is valued for its therapeutic properties, which have been cherished and passed down through generations. The essential oil extracted from Khus roots is renowned for its cooling and calming effects on the mind and body. In traditional medicine practices, Khus oil is used to alleviate various ailments, including stress, anxiety, insomnia, and inflammation. Locals often incorporate Khus oil into massage therapies, herbal remedies, and aromatic blends, harnessing its natural healing powers for holistic well-being.

Agricultural Applications and Soil Conservation:

Beyond its cultural and therapeutic uses, Khus plays a pivotal role in sustainable agriculture and soil conservation efforts in the Koshi region. The deep and fibrous root system of Khus plants makes them highly effective in soil erosion control, particularly in areas prone to flooding and landslides. Farmers strategically cultivate Khus along the edges of fields, embankments, and water bodies to stabilize soil, prevent sedimentation, and enhance water quality.

The intricate network of Khus roots acts as a natural barrier, binding soil particles together and reducing surface runoff during heavy rainfall. This not only prevents soil erosion but also helps replenish groundwater resources and maintain soil fertility. Moreover, Khus plants contribute to carbon sequestration and soil organic matter accumulation, mitigating the impacts of climate change and enhancing the resilience of agricultural landscapes.

Environmental Benefits and Biodiversity Conservation:

In addition to its agricultural significance, Khus provides a myriad of environmental benefits, contributing to biodiversity conservation and ecosystem resilience in the Koshi region. The dense foliage of Khus plants creates a microhabitat for a diverse range of flora and fauna, supporting indigenous plant species and wildlife populations. Birds, insects, and small mammals find refuge and sustenance amidst the lush canopy of Khus foliage, fostering ecological balance and biodiversity.

Furthermore, Khus acts as a natural bio-filtration system, purifying groundwater and mitigating the impact of pollutants and contaminants. Its extensive root system absorbs excess nutrients, heavy metals, and other pollutants from the soil, preventing them from leaching into water bodies and causing environmental degradation. This eco-friendly mechanism not only improves water quality but also enhances the overall health of aquatic ecosystems, benefiting both humans and wildlife alike.

Socio-Economic Opportunities and Livelihood Enhancement:

Beyond its cultural and environmental contributions, Khus presents socio-economic opportunities for communities in the Koshi region, particularly for rural households dependent on agriculture and allied activities. Local farmers engage in the cultivation, processing, and marketing of Khus roots and essential oil, creating livelihoods and income streams for themselves and their families. The demand for Khus products in domestic and international markets provides a sustainable source of revenue, contributing to the socio-economic development of the region.

Moreover, Khus cultivation and processing generate employment opportunities along the value chain, including harvesting, sorting, drying, distillation, and packaging. Small-scale entrepreneurs and cooperatives play a vital role in aggregating Khus produce from local farmers, adding value through value-added processing, and marketing finished products to consumers.

This decentralized approach to Khus production and marketing empowers rural communities, fosters entrepreneurship, and promotes inclusive growth.

Challenges and Opportunities for Khus Cultivation:

Despite its numerous benefits, Khus cultivation in the Koshi region faces certain challenges, including limited access to quality planting material, inadequate infrastructure for post-harvest processing, and fluctuating market prices. Addressing these challenges requires concerted efforts from government agencies, research institutions, non-profit organizations, and private stakeholders to promote sustainable Khus cultivation practices, improve market linkages, and enhance value addition.

Investments in research and development, capacity building, and technology transfer are essential to enhance the productivity, quality, and profitability of Khus cultivation in the Koshi region. Introducing improved varieties of Khus with higher essential oil content, disease resistance, and drought tolerance can boost yields and enhance farmer incomes.
Similarly, establishing decentralized processing facilities for Khus oil extraction and value-added products can add value to the entire supply chain.

Furthermore, promoting eco-tourism and agro-ecological tourism initiatives centered around Khus cultivation and conservation can create alternative sources of income for rural communities while raising awareness about the importance of biodiversity conservation and sustainable agriculture. Engaging local youth in eco-entrepreneurship ventures related to Khus cultivation, eco-friendly tourism, and green enterprise development can harness their creativity, innovation, and leadership potential for sustainable development.

Conclusion

In conclusion, the Khus plant epitomizes the harmonious relationship between nature and culture, offering a plethora of benefits to the people and the environment in the Koshi region of Bihar. From its cultural significance and therapeutic uses to its agricultural applications and environmental contributions, Khus embodies the essence of sustainable living and holistic well-being. As we celebrate the timeless wisdom of Khus and its timeless contributions to our lives, let us strive to preserve and promote its legacy for future generations to cherish and benefit from. Through collective action and collaborative partnerships, we can harness the transformative power of Khus to build resilient, inclusive, and sustainable communities in the Koshi region and beyond.

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PROBIOTICS IN AQUACULTURE

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Abstract

Probiotics in aquaculture have gained significant attention as a sustainable approach to enhance fish health, growth performance, and overall aquatic ecosystem stability. The mechanisms by which probiotics exert their beneficial effects, including modulation of gut microbiota, enhancement of immune response, and inhibition of pathogenic organisms. Various strains of probiotics, such as *Lactobacillus*, *Bacillus*, and *Saccharomyces*, are evaluated for their efficacy across different species of fish and shrimp. Additionally, the impact of probiotics on water quality and feed efficiency is examined, highlighting their role in reducing reliance on antibiotics and minimizing environmental impacts. The integration of probiotics into aquaculture practices presents a promising strategy for improving production efficiency and ensuring the health of aquatic organisms in a sustainable manner. Future research directions include optimizing dosages, understanding strain-specific interactions, and exploring the long-term effects of probiotics on aquaculture systems.

Keywords

Probiotics, aquaculture, prophylactic, immunity, health management, supplemented feed

Probiotics

The term probiotic means life; it was derived from two Greek words ‘pro’ and ‘bios’. Probiotics are live microbes that can be used to improve the host intestinal microbial balance and growth performance. Development of probiotics in aquaculture management will reduce the use of antimicrobial drugs which were prophylactive alone and whose over dependence in recent times poses potential hazards to man who consume them.

Selection of Probiotics

The initial major purpose of using probiotics is to maintain or reestablish a favorable relationship between friendly and pathogenic microorganism that constitute the flora of intestinal or skin mucus of fish. A successful probiotic is expected to have a few specific properties in order to certify, a beneficial effect.

A healthy source of microorganisms from a digestive tract of healthy aquatic animals must be selected. The microorganisms with which the work is to be carried out are isolated and identified by means of selective culture. A new culture with only the colonies of interest for conducting in vitro evaluations such as inhibition of pathogens; pathogenicity to target species; resistance conditions of host; among others are performed. In case of the absence of restrictions on the use of the target species, experiments with in vivo supplementation, and small and large scale, are carried out to check if there are real benefits to the host.

Finally, the probiotic that presented significantly satisfactory result can be produced commercially and utilized.

Constraints to Probiotics in Aquaculture

1. Inability of strains to be produced in commercial quantities and consequent demonstrations on a large scale.
2. Difficulty in proving performance at the farm level.
3. Inability of companies to conduct extensive research on how to make product specifically for aquaculture purposes.

Probiotics Significance in Aquaculture

There are some possible benefits linked to the administering of probiotics which have already been suggested as:

1. **Improvement in Water Qualities**

Nitrogenous compounds contamination such as ammonia, nitrite and nitrate in fish culture systems/ponds has been a serious concern. The susceptibility of cultured aquatic species to high concentration of these compounds is generally species-specific, but in high concentrations, these compounds may be extremely harmful and cause mass mortality in all cases. The ability of *Lactobacillus* spp. JK-8 and JK-11 simultaneously removes nitrogen and pathogens from contaminated shrimp farms.

2. As Growth Promoters

It has been demonstrated experimentally that probiotics indeed may enhance the growth of fish. The ability of organisms to out-grow the pathogens in favour of host or to improve the growth of the host and yet no side effect on the host made it a probiotic bacterium. Probiotic bacteria as growth promoter on tilapia (*Oreochromis niloticus*) identified that the highest growth performance was recorded with *Micrococcus luteus* a probiotic and the best feed conversion ratio was observed with the same organism. So, *M. luteus* may be considered as a growth promoters in fish aquaculture. Lactic acid bacteria also had an effect as growth promoters on the growth rate in juvenile carp though not in Sea bass.

3. For Disease Prevention

Probiotics or their products for health benefits to the host have been found useful in aquaculture, terrestrial animals and in human disease control. These include microbial adjunct that prevent pathogens from proliferating in the intestinal tract, on the superficial surfaces and in culture environment of the culture species. The effect of these beneficial organisms is achieved through optimizing the immune system of culture organism, increasing their resistance to disease, or producing inhibitory-substance that prevent the pathogenic organisms from establishing disease in the host.

4. Source of Nutrients and Enzymatic Contribution to Digestion

Some researchers have suggested that microorganisms have a beneficial effect in the digestive processes of aquatic animals. In fish, it has been reported that Bacteroides and *Clostridium* spp. have contributed to the host's nutrition, especially by supplying fatty acids and vitamins. Some microorganisms such as *Agrobacterium* spp., *Pseudomonas* spp., *Brevibacterium* spp., *Microbacterium* spp. and *Staphylococcus* spp. may contribute to nutritional processes in *Salvelinus alpinus*. Microbiota may serve as a supplementary source of food and microbial activity in the digestive tract may be a source of vitamins, or essential amino acids.

5. Stress Tolerance

Intensive production of aquaculture results in stress in fishes. Zebra fish and European seabass stress were reduced by food supplemented with probiotics bacteria *Lactobacillus delbruecki* spp. Another way to assess stress in fish involves subjecting them to heat shock. In this method of stress reduced in Japanese flounder while fed with probiotics incorporated feed.

Sparus auratus fed with probiotics *Alterumonas* spp. showed decreased stress indicator levels of lactate and plasma glucose level.

6. **Enhancement of the Immune Response**

Among the numerous beneficial effects of probiotics, modulation of immune system is one of the most commonly purported benefits of probiotics. Fish larvae, shrimps and other invertebrates have immune systems that are less well developed than adult stage and are dependent primarily on non-specific immune responses for their resistance to infection.

7. **Antiviral Effect**

Some probiotic bacteria have properties of an antiviral effect. Strains of *Pseudomonas* spp., *Vibriosis* spp., *Aeromonas* spp., and groups of Cornyforms isolated from Salmonids hatcheries showed the antiviral activity against infectious hematopoietic necrosis virus with more than 50 percent plaque reduction.

8. **Effect on Reproduction of Aquatic Species**

Effect of probiotic supplementation on reproductive performance of fish was studied using *B. subtilis* isolated from the intestine of *Cirrhinus mirigala*. Probiotic incorporated at different concentration to fed species of ornamental fishes showed increase GSI, fecundity viability and production of fry.

Probiotics in Aquaculture Management

These organisms can be administered to the aquaculture management through feeding, injection or immersion of the probiotic bacteria.

1. **Application in Feed**

Probiotics are applied with the feed and a binder (egg or cod liver oil) and most commercial preparation contain either *Lactobacillus* spp. or *Saccharomyces cerevisiae*. According to FAO and WHO guidelines, probiotic organisms used in food must be capable of surviving passages through the gut i.e. they must have the ability to resist gastric juices and exposure to bile. Furthermore, they must be able to proliferate and colonize the digestive tract and they must be safe, effective and maintain their effectiveness and potency for the duration of the shelf life of the product.

2. **Direct Application to Pond Water**

The water probiotics contain multiple strains of bacteria like *Bacillus acidophilus*, *B. subtilis*, *B. lecheniformis*, *Nitrobacte*r spp., *Aerobacter* and *Sacharomyces cerevisiae*.

Application of probiotic through water of tanks and ponds may also have an effect on fish health by improving several qualities of water, since they modify the bacteria composition of the water and sediments.

3. Application through Injection

Application of probiotics by injection is a possibility. The possibility of freeze- drying the probiont like vaccine and applied either through bathing, or injection. The use of probiotics stimulates Rainbow trout immunity by stimulating phagocytes activity, complement mediated bacterial killing and immunoglobulin production.

Conclusion

Probiotics represent a transformative approach in aquaculture, offering numerous benefits for fish and shrimp health, growth performance, and overall ecosystem stability. Their ability to enhance immune responses, improve gut health, and suppress pathogenic organisms makes them a valuable alternative to traditional antibiotics, promoting sustainable farming practices. As the aquaculture industry faces increasing challenges related to disease management and environmental sustainability, the integration of probiotics can significantly contribute to healthier aquatic ecosystems and improved production efficiency.

Future research should focus on optimizing probiotic formulations, understanding species-specific responses, and evaluating long-term impacts on both aquatic organisms and their environments. By harnessing the power of probiotics, the aquaculture sector can move towards more sustainable practices, ensuring the health of aquatic species while minimizing ecological footprints. Emphasizing a holistic approach that incorporates probiotics will not only enhance productivity but also support the resilience of aquaculture systems in the face of changing environmental conditions.

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QUEEN REARING TECHNIQUES IN HONEY BEES

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Introduction

Queen rearing is the process of intentionally raising new queen bees in order to replace old or underperforming queens in a bee colony. It is an essential practice in beekeeping, as the queen is the heart of the hive, responsible for laying eggs and maintaining the colony's population. Queen rearing allows beekeepers to ensure the health and productivity of their hives by providing them with strong and genetically diverse queens. By carefully selecting and nurturing queen bees, beekeepers can maintain thriving colonies and increase honey production. Additionally, queen rearing techniques also encompass the process of introducing newly mated queens into beehives, ensuring a successful transition and integration into the colony.

Importance of queen rearing in beekeeping

Queen rearing techniques refer to the methods used by beekeepers to artificially raise queen bees. This process involves selecting specific female larvae and providing them with optimal conditions to develop into healthy and productive queens. With the decline in honeybee populations worldwide, due to factors such as habitat loss and pesticide use, it has become even more important to prioritize the breeding and propagation of strong, resilient queen bees. In addition to maintaining the health and productivity of the hive, queen rearing also plays a crucial role in the overall sustainability of beekeeping. By actively participating in queen rearing, beekeepers are not only ensuring the survival of their own colonies but also contributing to the preservation of these vital pollinators on a larger scale. Furthermore, queen rearing allows beekeepers to have greater control over the genetic traits of their colonies, enabling them to selectively breed for desirable characteristics such as disease resistance, honey production, and gentle behaviour. Overall, queen rearing is a fundamental practice in beekeeping that directly impacts the success and longevity of bee colonies, as well as the overall health of our ecosystems.

Methods of Queen Rearing

Natural Queen Rearing

Natural queen rearing is a method of allowing the bees themselves to select and raise their own queens. This process mimics the natural reproductive behaviour of wild colonies and is often favoured by beekeepers who prioritize maintaining genetic diversity and adaptability within their colonies. In natural queen rearing, the bees will select a few eggs or young larvae and feed them a special diet called royal jelly, which triggers their development into queen bees. The bees will then construct special queen cells in which the new queens will develop. This method relies on the bees' instinctual behaviour and requires minimal intervention from the beekeeper. However, it does have its limitations, as the bees may not always produce queens with the desired traits or characteristics.

Swarm-induced queen rearing

It is a method where beekeepers can use to intentionally induce the bees to raise a new queen. This method involves creating the conditions that mimic a natural swarming event, which triggers the bees' instinct to raise a new queen. The beekeeper can achieve this by providing the bees with ample space, a strong nectar flow, and a young and vigorous queen. By carefully manipulating these factors, the beekeeper can encourage the bees to produce a new queen with the desired traits and characteristics. This method allows the beekeeper to have more control over the genetics and adaptability of their colonies, ensuring the long-term health and productivity of their beekeeping operation.

Supersedure queen rearing

This involves selecting a colony with a strong and healthy queen, and then removing her from the hive. This prompts the worker bees to recognize the need for a new queen and begin the process of raising one themselves. The beekeeper can then introduce a queen cell, containing an egg or larvae, into the hive, allowing the worker bees to nurture and develop it into a new queen. This method of supersedure queen rearing is advantageous because it allows the beekeeper to choose specific traits and characteristics they desire in the new queen, such as increased honey production or resistance to certain diseases. Additionally, it provides an opportunity to replace an aging or underperforming queen, ensuring the overall strength and vitality of the colony.

Emergency queen rearing

Emergency queen rearing is another method used by beekeepers to quickly replace a lost or failing queen in a colony. This method is typically employed when a queen suddenly dies or becomes unable to fulfill her duties, leaving the hive at risk of collapse. In such situations, the worker bees may begin to create emergency queen cells, also known as supersedure cells, to raise a new queen. These cells are usually built vertically along the comb, as opposed to the horizontally placed queen cells used in supersedure queen rearing.

Artificial Queen Rearing

Grafting method

In artificial queen rearing, beekeepers have more control over the process of raising new queens. The grafting method is a commonly used technique in this approach. It involves carefully transferring young larvae from a healthy queen's brood comb into artificial queen cups. These cups are usually made of plastic or wax and are placed in a queenless colony or an incubator specifically designed for queen rearing. The larvae are selected based on their age, usually between 12 and 24 hours old, as they are still in the ideal stage for grafting. Once the larvae are successfully transferred, the worker bees in the colony will start feeding them with royal jelly, a special secretion produced by their glands. This nutrient-rich substance is essential for the larvae to develop into queen bees.

Queen cell cups - are carefully monitored by beekeepers to ensure that the larvae are receiving enough royal jelly. The cups are checked regularly to make sure that the larvae are healthy and developing properly. The process of raising queens in artificial queen cups allows beekeepers to control the breeding of their colonies and ensure the production of strong and productive queens. It is a delicate and precise process that requires careful attention and expertise.

Queen cell starters and finishers - are used by beekeepers to facilitate the development of queen bees in artificial queen cups. Queen cell starters are specialized colonies of bees that are specifically designed to rear queen larvae. These colonies are carefully managed and provided with an abundant supply of royal jelly to ensure optimal queen development. On the other hand, queen cell finishers are colonies that are responsible for completing the development of queen cells into fully mature queens. These colonies are carefully selected and maintained to provide the ideal conditions for queen cell maturation. Both queen cell starters and finishers play crucial roles in the successful rearing of queen bees, and their management requires extensive knowledge and experience in beekeeping techniques.

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MECHANISMS OF AMR (ANTIMICROBIAL RESISTANCE) TRANSFER

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Abstract

Antimicrobial resistance (AMR) poses a significant threat to global health, primarily due to the ability of resistant microbes to transfer their resistance mechanisms. Key mechanisms through which AMR is transferred among microorganisms, including horizontal gene transfer (HGT), plasmids, transposons, and integrons. HGT allows for the exchange of resistance genes through transformation, transduction, and conjugation, facilitating rapid spread within and between species. Plasmids, small circular DNA molecules, often carry multiple resistance genes and can replicate independently of chromosomal DNA, promoting adaptability. Transposons, or "jumping genes," enable the mobilization of resistance genes within and between genomes, while integrons capture and express gene cassettes, further contributing to resistance diversity. Environmental factors, such as antibiotic use and pollution, exacerbate AMR transfer, highlighting the urgent need for integrated surveillance and intervention strategies to mitigate its impact. Understanding these mechanisms is crucial for developing effective approaches to combat AMR and protect public health.

Keywords

Antimicrobial resistance (AMR), Horizontal gene transfer (HGT), antibiotics, resistance genes

Introduction

Infections caused by antibiotic-resistant microbes are the cause of mortality by 2050. AMR is one of the major public health concerns. Antibiotics are utilized in aquaculture and animal husbandry not only as treatments but also as prophylactics, growth promoters, and enhancers of feed efficiency. Thus, irrational use of antibiotics has led to emergence of AMR in microorganisms. However, the AMR emergence and spread cannot be strictly attributed exclusively to the misuse of antibiotics, growing research has identified the indirect effects of the biocides, chemicals, heavy metals present naturally and being used in the production systems and climate change as inducers for the selective pressure in bacteria contributing to the scenario. Bacteria can directly acquire resistance mechanisms from other bacteria through Horizontal Gene Transfer (HGT) or develop resistance as a result of exposure to sub-inhibitory amounts of antibiotics in their environment.

Increased research has been done on this topic due to evidence that not only antibiotic resistance genes (ARGs) found in clinical pathogens are relevant, but also all pathogenic, commensal, and environmental bacteria, as well as mobile genetic elements and bacteriophages, form a reservoir of ARGs from which pathogenic bacteria can acquire resistance via horizontal gene transfer (HGT).

Horizontal gene transfer

Horizontal gene transfer (HGT) is a highly effective and rapid method of transmitting resistance between populations. It is the most relevant way for microbial populations to develop and spread resistance. The main methods of horizontal genetic material transmission between are transformation, transduction, and conjugation (Figure 1).

Among these, conjugation is identified as the major player in AMR transfer. HGT results in dissemination of ARGs from commensals and environmental bacteria to the pathogenic ones and causes concern for clinicians.

1. **Transformation**

The process by which bacteria absorb DNA from their surroundings through their cell membrane is known as transformation. It has been observed that some bacteria possess an innate ability to absorb, integrate, and produce functional pieces of extracellular DNA through a process known as transformation. Subsequent research revealed that bacteria might utilize transformation to take out ARGs and avoid antibiotics. But in order for bacteria to convert, they must be competent enough to absorb any extracellular DNA. Numerous elements, including the presence of inducers, stressful environments, and antibiotics, can cause bacteria to become competent.

2. Transduction

Bacteriophages use a method called transduction to convey genetic material to their hosts and modify the environment for reproduction and survival. The genetic material that can be transferred includes chromosomal DNA and mobile genetic elements (MCT), which consist of integrons, transposons, and plasmids. The transduction of a variety of ARGs by bacteriophages in diverse bacterial communities and environments plays a major role in the dissemination of ARGs in microbial ecosystems. Bacteriophages are reported to have a wide host range that crosses between different species and may extend to taxonomic classes.

3. Conjugation

Bacterial conjugation is the process by which genetic material is transferred from one bacterial cell to another, either directly or by a link that resembles a bridge. Since bacterial conjugation involves the exchange of genetic material, it is frequently thought of as the bacterial counterpart of sexual reproduction or mating. The donor cell supplies a conjugative or mobilizable genetic element—typically a plasmid or transposon—during the conjugation process.

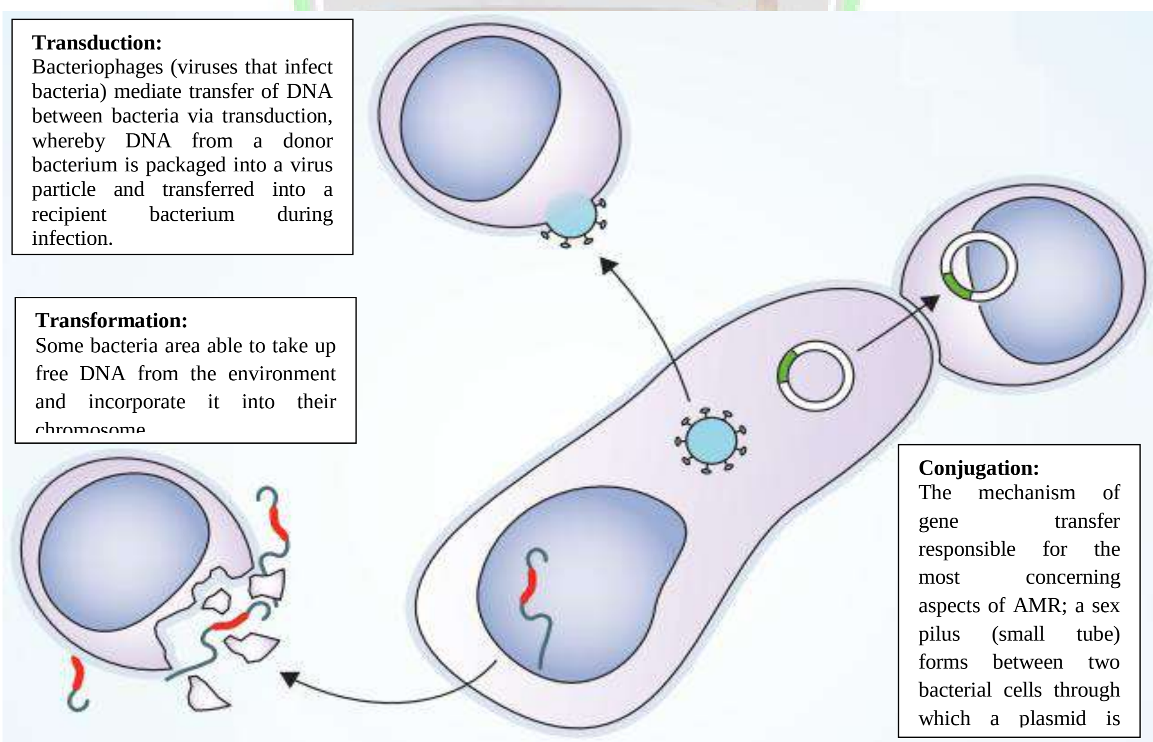

Fig. 1: Transmission of genetic material between microorganisms (Holmes et al., 2016)

Mobile Genetic Elements (MGEs)

1. **Plasmids**

Extra chromosomal DNA known as plasmids is capable of independent replication within bacterial cells. In the natural world, plasmids frequently carry genes, such antibiotic resistance, that could help an organism survive. While plasmids are typically relatively small and contain just extra genes that may be relevant to the organism under specific scenarios or settings, chromosomes are large and carry all the genetic material necessary for life under normal conditions. Rplasmids are plasmids that contain resistant genes, or "r-genes." It is easy to move these r-genes from one R-plasmid to another or to a chromosome. Plasmid-mediated gene transfer accounts for a significant portion of drug resistance seen in clinical settings.

2. **Transposons**

A DNA sequence known as a transposable element (TE or transposon) has the ability to move around inside a genome, often causing or reversing mutations that affect the genome of the organism. Another name for these is leaping genes. They have the ability to transfer genetic material between plasmids and bacterial chromosomes.

3. **Integrons**

By ensuring their proper expression, integrons serve as assembly platforms that integrate exogenous open reading frames via site-specific recombination and transform them into functional genes. Genes contained within gene cassettes (GC) are acquired, exchanged, and expressed by integrons. Integrons are widely dispersed, particularly in Gram-negative bacteria; transposons, plasmids, and mobile genetic elements all carry them, aiding in their dissemination throughout bacterial communities. They are said to be crucial in the environmental transmission of AMR. Integrons can be transferred between species.

Conclusion

In conclusion, the mechanism of antimicrobial resistance (AMR) transfer is a complex interplay of genetic, environmental, and microbial factors. Key processes include horizontal gene transfer through transformation, transduction, and conjugation, which allow resistant genes to spread rapidly among bacteria. Environmental pressures, such as antibiotic use in healthcare and agriculture, further accelerate this process.

Understanding these mechanisms is crucial for developing effective strategies to combat AMR, including improved antibiotic stewardship, infection control measures, and research into novel therapies. Continued surveillance and education are essential to mitigate the impact of AMR on public health. By addressing the root causes and pathways of AMR transfer, we can work towards preserving the efficacy of existing antibiotics and protecting future generations from resistant infections.

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PROSPECTS OF PROTECTED CULTIVATION OF FLOWER CROPS IN UPPER & LOWER PULNEY HILLS

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Introduction

Today, floriculture through protected structures has emerged as a viable diversification option in the agri- business. Rapid urbanization, increased income levels, changes in life styles and social values resulted in increase in domestic market for cut flowers. Floriculture industry is growing and is providing better income to the farmers as flower consumption is increasing. Among flower crops cut flowers has become important and there is appreciable growth in export.

Tamil Nadu continues to take the first place in the production of loose flowers in the Country, the production being 5.15 lakh MT during the year 2021 – 2022. Tamil Nadu takes the third place in regard to area, by cultivating the flowers in an area of 42,920 Ha (NHB, 2022) and Dharmapuri, Salem, Dindigul, Krishnagiri, and Tiruvannamalai districts play a major role in achieving the target. Assistance is extended for cultivation of loose flowers, bulbous flowers and cut flowers. Quality planting materials are being produced in State Horticulture Farms and distributed to farmers in subsidized cost to encourage flower cultivation.

In India, 98.5 per cent of flowers are grown under open condition and hardly 1.5 per cent flowers are grown under protected structures. That's shows that Hi- Tech floriculture industry is still in its infancy. However, in the recent past, floriculture has been considered as a viable option for diversification in horticulture due to domestic and export potential particularly for cut flowers like Carnation, Gerbera, Cut Roses, Lisianthus, Orchids, Anthurium & Bird of Paradise etc.

Availability of natural resources like diverse agro climatic conditions permits production of a wide range of temperate flowers, almost all through the year in some part of the country or other. Improved communication facilities have increased their availability in every part of the country. The commercial activity of production and marketing of floriculture products is also a source of gainful and quality employment to scores of people.

Floriculture

India has an ancient heritage when it comes to floriculture. Floriculture has emerged as an economically viable diversification option in the Indian agribusiness and has captured the interests of many new entrepreneurs into agricultural sector in recent times. With perception on floriculture business potential rapidly changing, the corporate have increasingly forayed into the sector. Indian roses, carnations, orchids, gladiolus and anthurium are being well received in Japan, Netherlands, USA, Germany and France. Besides flowers, India also exports seeds, bulbs, dried flowers, ferns, leaves and grass. Floricultural crops like roses, gerberas, carnations etc. are grown in poly house commercially.

Lower and Upper pulney hills

In lower and upper pulney hills the cut flower industry was started as an attractive business opportunity and motivated us one of the entrepreneurs in the sector. Really, cut flower industry in this region is option and best alternative for traditional crop cultivation. During 1961, Government of India started central Sheep and Wool Research Station at Mannavanur and in the same year Horticultural Research Station, Kodaikanal was established to promote Apple, Almond, Almond, Walnut, Kiwi, Persimmon, Pear Peach, Potatoes, Carrot, Peas & Beans, Gerbera, Carnation, Lisianthus, Gladiolus, Alstroemeria and Geranium. Some farmers started Geranium, rosemary and lemon grass cultivation. The area of cultivation extended considerably and Forest Department leased the grass lands for cultivations of potato for conversion of the land to commercial plantations of Eucalyptus and wattle for pulpwood and most of the grass lands have been converted in the Forest plantation. Latter forest department dropped Kumari lease for cultivation of potatoes due to heavy erosions and silt nearby dams.

Asiatic lilium cultivars under Poly tunnel structures at HRS, Kodaikanal

Till 1984, the forest department was selling the pulp wood to paper mills and viscose factories due to shortage of the supply from forest department. The pulp wood company, South India Viscose started their agricultural land into Eucalyptus plantations due to uneconomical usage of fertilizers for their potato and vegetable cultivations. Farmers sold their pulp wood to these companies through local traders, then the farmers slowly started convert these lands for potato and vegetable cultivation. Those who have swamps and streams by converted into percolation tanks and started cultivation round the year. The farmers, small and medium are able to generate only low income due to increased cost of seed material, fertilizers and chemicals. At this stage, Floriculture is commercially introduced as a viable diversification from the traditional field crops due to higher returns per unit and the increasing habit of "Saying it with flowers" during all occasions.

Performance of Gerbera cultiavrs under Polutunnel Structure at HRS, Kodaikanal

Performance of Eustromas cultivar under Polyhouse in farmers field at Kounchji, Kodaikanal

In year 2002 to 2005 farmers started cultivating Carnation, Gerbera and Lilliums in wooden poly house of 500 sq.m and Department supported with subside under RSVY scheme to the time of Rs. 40,000 to Rs. 1, 00,000. About 40 farmers at Kavunji, Pannaikadu, Thandikudi and Kodaikanal areas were planted the cut flowers under commercial venture.

Later, in the year 2007-08 farmers of this region started cultivation of cut flowers under steel structure green house with 50% subsidies for 1000 sq.m. under National Horticultural Mission by the Department of Horticulture, Tamil Nadu. Farmers are motivated with the cultivation of Carnation, Gerbera, Lilliums under green house, Anthurium under shade net, Bird of paradise, Alstroemeria, Statice under open field. Now about 100 farmers are engaged in cut flower cultivation under poly house producing about 1.25 crore of Carnation and 50 lakhs flowers of other cut flowers from Kodaikanal and for the benefit of growers 'Cut Flower Growers Association' was started in Kodaikanal.

The following cut flowers were grown under protected cultivation in Kodaikanal.

Table.1.Varieties cultivating in upper & lower pulney hills under poly house

S.No.	Cut flowers	Varieties
1.	Cut roses	First Red, Grand Gala, Ravel, Konfetty, Bianca, Pretty Women
2.	Carnation	Killer, Malaga, Delphi, Madame Colette, Varna, Solar , Lady Green, Estimade, Indira, Vera, Durago, Amore & Kissisiga
3.	Gerbera	Sunset, Neveda, Sangna, Lynx, Macho, Vino, Venture, YCD-1 , YCD-2,Tecla, Carocci, Noblesse, Harmony, Flavia, Gescom, Cassiana, Ambra, Red Star, Dana Ellen, Dalma, Goliath, Rosalin, Quote, Salvadore, Balane, Jaffa, Sangria, Rosula, Oprab, Romona, Salina, Tecora & Starlight
4.	Lisianthus	Avila, Balboa, Catalina, Ventura, Malibu,& Laguna
5.	Lillium	All round, America, Brunello, Casa Bella, London, Star Gazer, Star Fighter, Crystal Star, Elegant Lady, Corno, Gironda, Marusa, Yellow Wein , Drunella & Snow Queen

Table. 2. Cut Flowers varieties under open condition

S.No.	Cut flowers	Varieties
1.	Gladiolus	Pusa Gunjan, Pusa Bindiya, Pusa Subhangini, Nazrana, Punjab morning, Punjab Dawn, Kumkum, Chaubattia, Arunima, Tiger flame, Summer Pearl, White Prosperity, Interped,Jester, Candy Man, Pacifica, Red Majesty, American Beauty & Green Bay
2.	Alstroemeria	Aladdin, Pluto, Primadonna, Nemo, Debora, Ovation, Chapeau, Twister, Pumori, Avalange , Fuji, Virginia, Himalaya, White Forest, Dimention, Senna, Honney Bell, Shakira, Cote d'Azur, Napoli, Chicago, Fuego, Doris, Nadya, Orange Queen, Tampa, Firenze, Sunny Rebecca, Mistique, Rembrandt, & Mayfair
3.	Bird of Paradise	Mandella's gold, Red, Yellow & Mexican
4.	Orchids	Moth orchids, Doritaeonopsis, Oncidium (dancing lady), Papheopedium hybrid, *Dendrobium phalaenopsis* & Cymbidium
5.	Breanthus	Coconut punch, Coconut surprise, Cranberry Ice, Fire Star, Fire Witch, Heart attack, Raspberry swirl, Raspberry surprise, Neon star Shooting Star, Zing Star, Eastern Star, Spangled Star, Brilliant Star, Barbarini Red,& Sooty

Constraints

Even though the upper and lower pulney hills is blessed with proper climate condition suitable for cut flower cultivation the farmers are facing lot of problems in production and marketing due to fluctuation in price for cut flowers. It is absolutely necessary that Government should facilitate the growers by providing financial assistance and technical support.

1. Financial assistance for pack house establishment exclusively for cut flowers to facilitate marketing.
2. Provision of cold chain management for cut flowers.
3. Supply of quality inputs for Hi-Tech production of cut flowers under subsidized cost.
4. To improve knowledge on production, frequent trainings and farmer's exposure visit may be arranged in National and Inter National level.

5. Farmers are not aware on timely supply of quality planting materials. Hence Hi-Tech nursery and plug plant industry may be established in this region.

Future trust

1. Expansion of area of cut flowers under poly house through introduction of promotional schemes
2. Introduction of high yielding and new improved varieties suitable for domestic and export market.
3. Standardization of micro irrigation and fertigation techniques.
4. Create facilitation for Postharvest, storage, packaging, forwarding and transportation.

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GRAFTING – BASIC TECHNIQUES IN VEGETABLE CROPS

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Introduction

Since the beginning of civilization, fruit and nut trees have been grafted because of the difficulty in propagating by cuttings and the superiority and high value of the grafted crop. New markets continue to require grafted plants for improve plant quality, fruit yield, superior forms and better adaptation to greater ecological. Also with the greater reliance on integrated pest management and more usage of pesticides and soil fumigants, disease tolerant rootstocks are playing a greater role in most of the horticultural crops.

History

The origin of grafting can be traced to ancient times. There is evidence that the art of grafting was known to the Chinese at least as early as 1560 B.C. Large number of new plants from foreign countries were imported into European garden and maintained by grafting. Starting from ancient time till now new methodologies and research were taken by the many scientist in grafting and revealed good results.

Commercial grafting of vegetables began in Korea and Japan in the late 1920’s when watermelon plants were grafted onto squash rootstock for Fusarium wilt resistance eggplant was grafted onto scarlet eggplant rootstocks (*Solanum integrifolium*) in 1950’s. Since then, grafting has been adopted in Asia and Europe for various protected production systems including greenhouse and high tunnels. Currently, more than 95 percent of cucumber and watermelons, more than 54 percent of tomatoes grown in SouthKorea and japan are grafted. In China, almost all cucumber and most tomato, and watermelon and eggplants are grafted for winter production in unheated solar plastic greenhouse or low tunnels. In the Mediterranean region, grafting has been a major component of integrated management on soil borne diseases and increasing crop productivity.

Grafting

Grafting is the art of joining two pieces of living plant tissue together in such a manner that they will unite and subsequently grow and develop as one composite plant.(compound plant).

The important compound involved in grafting is

(a) Scion (shoot system)

(b) Rootstock (understock, stock)

Scion

It becomes the new shoot system of the graft. It is composed of a short piece of detached shoot containing several dormant buds which, when united with the rootstock, comprises the upper portion of the graft and from which will grow the stem or branches, or both of the grafted plant. The scion should be of the desired cultivar and free from disease.

Rootstock

It is the lower portion of the graft, which develop into the root system of the grafted plant. It may be a seedling, a rooted cutting, a layered or micro propagated plant.

Methods of Grafting in Vegetables

Grafting Technology

A.Techniques

Grafting is a process that involves

(1) Choice of stock and scion species

(2) Creation of a graft union by physical manipulation

(3) Healing of the union and

(4) Acclimation of the compound plant.

1. Conventional Manual Grafting

There are numbers of methods applicable for conventional herbaceous grafting. Some of the most frequently used methods are

1.1 Tounge approach grafting

1.2. Hole insertion grafting (HIG)

1.3. Splice grafting

1.4. Cleft grafting

1.5. Pin grafting others

1.1. Tounge Approach Grafting (TAG)

Mostly the conventional grafting is carried on by growers or by commercial plug seedling nurseries. TAG is the oldest method and perhaps the most convenient grafting methods for herbaceous plant. The method can be used for basically any kind of plants such as cucurbits, solanaceous plants and many other types.

The seeds of the scion are sown five to seven days earlier than rootstock seeds. The growing point of the rootstocks should be carefully removed before grafting to reduce the unnecessary loss of nutrient for the bud growth and to promote the rapid union of graft interface.

The grafting cut for rootstock should be made in a downward direction and the scion cut in an upward direction at an angle of 30º to 40º to the perpendicular axis and deep enough to allow the fusion of as many vascular bundles as possible. A specially designed clips are placed to fix the graft position. The grafted plants are partially shaded for one or two days before placing them under normal growing conditions. The survival rate is higher but need more laborers' for grafting and cutting the rootstock again.

1.2. Hole Insertion Grafting (HIG)

This is also termed as terminal graft/top insertion graft. It is most popular cucurbit grafting method in china. Scion seeds should be sown eight days after the sowing of rootstock. Both the scion and rootstock should be uniform and strong enough to take the graft operation. The true leaf including the growing point should be carefully and thoroughly removed and a hole is made with a bamboo or plastic gimlet or drill at a slant angle to the longitudinal direction. The hypocotyl portion is prepared by slant cutting to have a tapered end for easy insertion. Care should be given to avoid the insertion into the stem pith since this greatly interferes with formation of a rapid union and facilitates later protrusion of adventitious roots into soil after downward elongation through the pith cavity of the rootstock. HIG requires skill level as compared to TAG.

1.3. Splice Grafting (SG)

It is very popular among experienced growers and commercial plug seedling nurseries. Intact or excised rootstock seedlings may be used depending on the grower's preference. For cucurbit rootstock, one cotyledon and the growing point are removed for grafting. After placing the scion on the rootstock ordinary grafting clips as in the TAG are used to fix the grafted position tightly together.

For solanaceous crops grafting is usually made at lower epicotyl and fixed with ordinary clips, elastic, tube-shaped clip with side slit or ceramic pins developed specially for this type of grafting.

1.4. Cleft Grafting (CG)

Mostly followed in herbaceous plants which is different from those of woody plants. Usually a portion of the stem is cut longitudinally. The rootstock seedlings are decapitated and longitudinal cut is made in a downward direction, 1 to 1.5 cm long and ¾ depth of the stem diameter. The scion is pruned to have one to three true leaves and the lower stem is cut to slant angle to make a tapered wedge (V-shaped). After placing the scion into the split made on the rootstock, a clip or plastic sheet is placed to hold in position until it unites.

1.5. Pin Grafting (PG)

It is similar to splice grafting, but instead of placing grafting clips to hold the grafted position, specially designed pins are used to hold, the grafted position in place. Even bamboo pins, rectangular in cross section shape could successfully replace the expensive ceramic pins at much lower price.

monitoring Grafting Success

The grafting success can be monitored by the emergence of new sprouts which starts after 15-20 days with successful grafting, water moved smoothly from the root to leaves of the scion, decreasing temperature due to transpiration, generally seedlings with thicker leaves are better for grafting because thicker leaves can maintain higher moisture content facilitating faster graft union.

Adaptation of Methodology

Even though many methods have been discussed, the most adaptable method by farmers and others are cleft grafting especially in solanaceous vegetables, which is easier and per day grafting rate is high. The method is given below.

Advantages

1) Grafting impart disease resistance or hardiness, contributed by the rootstock
2) Resistance to root knot nematode.

3) Increased yield by extended the harvest period.
4) Impart abiotic stress resistance (drought, heavy metals, salt etc).
5) Simple technology which can be easily acceptance adopted by farmers.

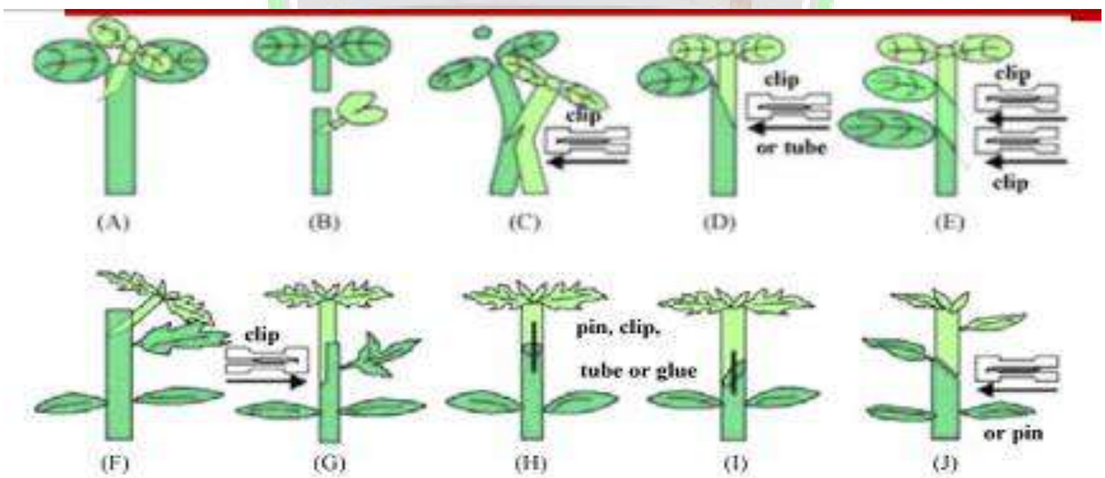
Disadvantages

1) Initially caring.
2) Involvement of skilled laborers.
3) Continuous pinching of rootstock suckers below the grafted portion.

Grafting Technique Followed in Vegetables

Vegetable crops coming under the family solanaceae and cucurbitaceaae are highly practicing the grafting techniques. The crops are

- ❖ Solanum melogena
- ❖ Lycopersicon esculentum
- ❖ Capsicum annuum
- ❖ Cucmis melo
- ❖ Citrullus lanateus
- ❖ Momordica charantia etc.



Different Grafting methods

A and B - Hole Insertion Grafting
C - Tongue Approach Grafting
D, E and J - Splice grafting
F,G - Cleft grafting
H and I - Pin grafting

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A PERSPECTIVE ON VIRULENCE FACTORS SHAPING *SALMONELLA* EVOLUTION IN AQUATIC FOOD

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Abstract

Salmonella causes gastroenteritis and typhoid fever and is commonly described as a facultative intercellular pathogen. Virulence potency to show the ability of bacteria to cause disease and express the level of pathogenicity. Globally, *Salmonella* is one of the concern pathogens encoded by severe virulence factor. It will adopt several mechanisms to develop an evolved bacterium with a high virulent determinant. The evolution directly or indirectly influenced the antimicrobial resistance and made it difficult to treat the disease. Therefore, knowledge of *Salmonella* virulence becomes an explorable one to control the disease and manage food safety.

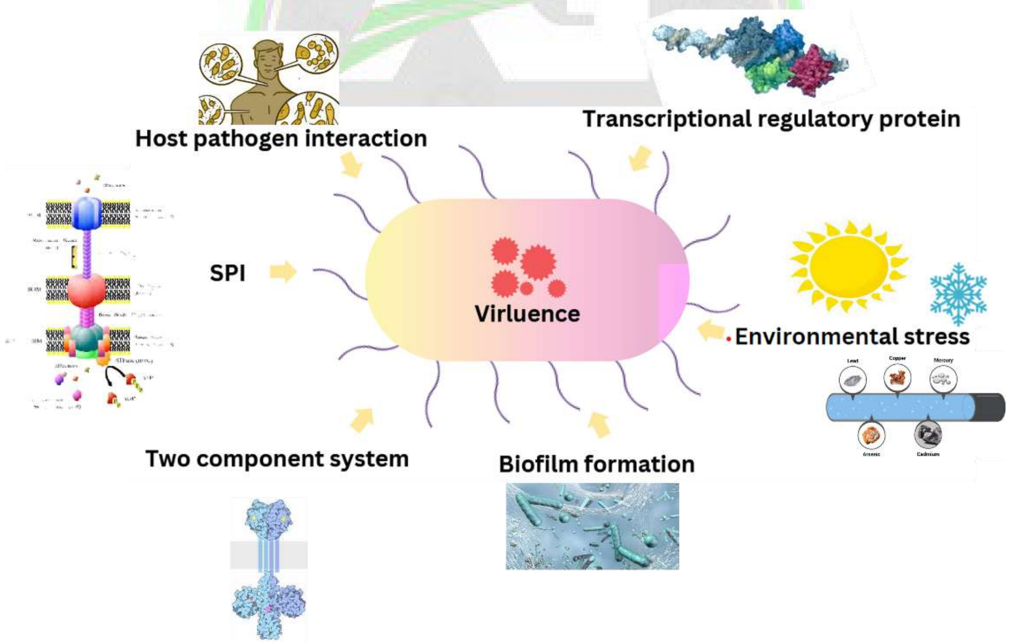
Keyword: Salmonella, virulence, intercellular survival, infection, aquatic food

Introduction

Food borne pathogens of *Salmonella* have ahigh magnitude of virulence and increases the severity of disease. Transmission of the *Salmonella* pathogen majorly linked to the aquatic food product whilst it might readily expose the infection in consumer. *Salmonella* progressed the virulence through several mechanisms, particularly the developed the genes, protein, chemical compound like biotoxin, quorum sensing and plasmids. *Salmonella* outbreaks from seafood pose a significant public health challenges and the huge incidences happened in world-wide and these bacteria had a significant role in outbreaks of foodborne diseases and septicaemia, as has raising of morbidity and mortality (Han et al., 2024). Ingestion of the cell of *Salmonella* that colonies in the intestine for certain period and, led predominant infection such as typhoid and paratyphoid fever. In addition, these infectious disorders can cause neurological symptoms, leukopenia, septicaemia, and immunological signs. These complications can sometimes lead to deaths in severe cases. Comparable to past decade, re-emerged the *Salmonella* infection through seafood and rise as high potent pathogenicity. The virulence factor act be the most prime attribute for the accelerate the pathogenicity in *Salmonella*.

Virulence potency of Salmonella

Salmonella acquired the virulence potency through two component system, Salmonella pathogenicity island, quorum sensing, regulation of sRNA, nutrient sensing, stress response, transcriptional regulator and intercellular pathogenicity interaction. *Salmonella* has adopted intercellular survival and replication through invasion or phagocytosis. Two component system play a prime role in the evolution of the virulence in *Salmonella*. Majorly, PhoP-PhoQ, SpiR/SsrB and CpxRA involved for virulence.



Virulence transferred between the population through horizontal transfer of gene, biofilm formation, adaptation of stress, alteration on metabolism and genes. It expressed virulence potency dependent on two type III secretion systems (T3SS1 and T3SS2), ion transporters, superoxide dismutase, flagella and fimbriae are also invaded on the host cell and lead the severe infection (Ibarra and Mortimer, 2009). SPI (Salmonella Pathogenicity Island) is the genetical element on chromosome which encrypted the notable of virulence genes. *Salmonella* survived and replicated through the adaptation of Salmonella-containing vacuole (SCV). SCV has prime responsible marker to prevent from the lysosomal activities. Subsequently, the *Salmonella* adopted by the filament alteration to attached with membrane for inter membrane of the intestine.

Responsible gene for virulence

Salmonella have more than 2500 variants of serotypes report in world. Many serotypes dominated on the pathogenicity by the means of virulence factor and presence of genes leading to disease outbreak. Even though it evident that *Salmonella enterica* had the maximum of virulence genes and it make distinct characteristics. *Inv*A has most significant led the infection by invasion on the intestine. Following that the expression of *Iro* B and *spi*C to escape from immune response (Mthembu et al., 2019) and Surface associated protein of *Bap*A and *Sii*E exhibited for invasion and adhesion (Gerlach et al., 2007). Considerable virulence genes are *ssa*R, *spv*C, *pef*A, *sip*A, *fim*A, *sif*A, *sop*E2, *sop*B, *prg*H, and *stn* which present in the *Salmonella* (He et al., 2024).

rnc gene,observable high virulence genes which encodes the RNase III ribonuclease. role of rnc tiggered superoxide dismutase SodA in *Salmonella* elicited to survive from the host immunity. This gene mainly reducing the deposition of dsRNA which could stimulated the host immune system (Chan et al., 2024). *Salmonella enteriditis* have significant genes with peculiar role and the genes were *fae* (fimbrial adherence determinants), *shd*A (nonfimbrial adherence determinants), the *rck* gene (invasion) and Plasmid-encoded fimbriae genes (pef A, B, C, D) (Vinueza et al., 2023). Through the phage, *Salmonella* survived in invaded host by the genes of *sop*E *and gip*A in the Peyer's patches. Most of the plasmid and phage associated virulence gene are located on the SPI3 and SPI5 site of chromosome. *pip*B gene conferred to collaspse the systematic immune system and dimnessed the specific function. *mgt*C gene in SPI3 entered invaded the hosts macrophage.

Regulatory mechanisms for virulence

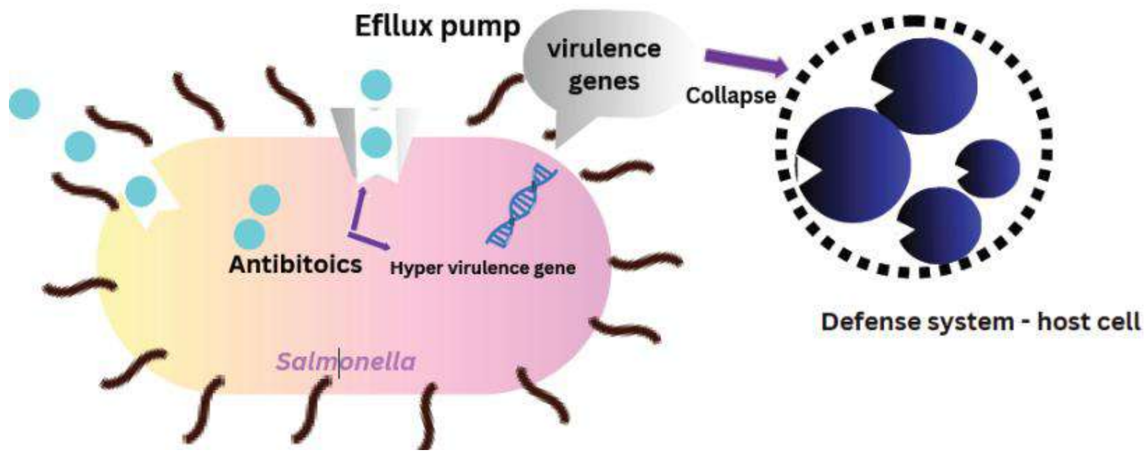
Salmonella conferred the quorum sensing mechanisms to invasion on intercellular survival in host or consumer. The bacteria communicated through signalling then it would able to tolerated the harsh environmental stress and promptly developed it virulence determinant

(Zhang et al., 2022). Two component system was the curical for virulence in *Salmonella*. The invasion of rck protein belong to family of outer membrane porin and promote the invasion of host cell for survival and lead the infection (Koczerka et a., 2021). The BarA/SirA and Csr global regulatory systems, positively regulate expression on the SPI-1 genes. Nevertheless, Salmonella required the BarA/SirA and Csr for the development and expression of virulence (Nava-Galeana and Bustamante, 2023). *Salmonella* commonly employ RNA-binding proteins (RBPs) and small regulatory RNAs (sRNAs) to regulate and promote the gene expression at intracellular virulence function. Effector protein activate the Salmonella plasmid virulence gene for host regulated cell death.

Interlink between virulence and antimicrobial resistance

Recently, *Salmonella* developed it resistance for several antibiotics and it also purposively linked to the virulence but it not clearly about mechanisms. Resistant profile of ACSSuT+ R-type had associated with the hypervirulence through the horizontal transmission of plasmid. inv A would exist in the multidrug resistant serotype of *Salmonella* (Dahshan et al., 2010). The class 1 integron had exhibit the cluster of antimicrobial resistance genes found in *Salmonella*. Efflux pump (AcrAB-TolC) might responsible for the infection and prominently it would eliminate the antibiotics. In absence of the antibiotics, efflux pump providing some virulence function. Specifically, the acquisition of antibiotic resistance to adapt and survive in adverse environments and virulence genes are defeated the host immune system. The fact of relation between the antibiotic resistance and rising of the virulence potential defined, that efficacy of antibiotic was reduced and make difficult to treat the illness. However, synergistic effect of antibiotic resistance and mutate virulence factor could make severe invasion and it has been ever survived harsh condition.

Occasionally, virulence of the bacteria can diminish during the acquisition of resistance to vast antibiotics. In virulence genes, majorly ssaQ associated with the devleopment antimicrobial resistance in *Salmonella*, contrary *mgt*C genes reduced resistance on intercellular survival. The class 1 integron gene and antibiotic resistance, as integron gene cassettes are known to carry genes that encode resistance to antibiotics. Therefore, evolution on antimicrobial resistance and virulence factor become most dangerous to comsumer and exposed as challengeable one in world-wide.



Future orient prevention initiatives

Salmonella evolved with high profile profile that creat stress on medication and control of disease outbreaks. Considering of that constant monitoring of the food quality, virulence profile of *Salmonella* and antimicrobial resistance pattern for the prevention of *Salmonella* infection. Inhibition of quorum sensing of *Salmonella* not showed changes in virulence, and perturbing regulatory networks is a promising strategy for the development of anti-infectives.

Conclusion

Salmonella has the multifaceted development strategies to suvive and outbreak the disease. It can adopt the several regulatory system and mutant gene to adopt the host environment. The bacterium contaminated through food or water and recently, Salmonella outbreaks recorded from the seafood. It led severe illness sometimes it causes death. Based on the health concern for monitoring virulence factor was carried and important task to prevent the severity od disease.

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UNVEILING THE SECRETS OF SOURSOP: A NUTRITIONAL POWERHOUSE AND NATURAL REMEDY FOR COMMON AILMENTS

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Introduction

Soursop - *Annona Muricata,* exotic fruit belongs to family of Annonaceae. It is native to the tropical regions of Americaand the Caribbean. It is commonly called as '*Mullseetha' in* Tamil Nadu. It is widely propagated through cuttings, Grafting and Air layering. Flowers are hermaphrodite; fruits are large and green in colour with spiky fruits, size of 8 - 12 inches. Both the leaves and fruits are filled with abundant nutritional properties. Peels and seeds are inedible parts of soursop fruit; there is a high amount of by products from this fruit as a source of bioactive compounds. It has anticancer activity included in cytotoxic activity against cancer cells and also it has many health disease treatments such as preventing hemorrhoid, reducing cholesterol, eliminating acne, fever, respiratory illness, malaria, liver, heart and kidney.

NUTRITIONAL PROPERTIES

Leaf and fruit contains many secondary metabolites compounds alkaloid, saponin, terpenoid, flavonoid, coumarin, lactone, anthraquinon, phenol, Flavonoids and phytosterol. The alkaloid *Annonaceous, Acetogeneins* (phytochemical) are found in Annonaceae family. They are strong inhibitor of enzyme processes that are found only in membrane of cancerous tumour cells. Antioxidants from outside the body are needed (exogenic) such as flavonoids, vitamin A, vitamin C and vitamin E presented in soursop is an excellent sole source. Particularly the flavonoid 2-phenyl-4H-1benzopyran-4-one has chemo preventive effects. It is reducing the occurrence of many types of cancers reported by Afzaal *et al.,* 2022

ANTI DIABETIC EFFECT

It is fruit pulp has around sixteen phenolic compounds. The pericarp of the fruit has the highest α-amylase and α-glucosidase. The key enzymes involved in the hydrolysis of starch and absorption of glucose. It has reduced high risk of the Type II diabetes.The whole plant extract is increases the white blood cells, lymphocytes, platelet count, blood cells, hemoglobin concentration, and packed cell volume.

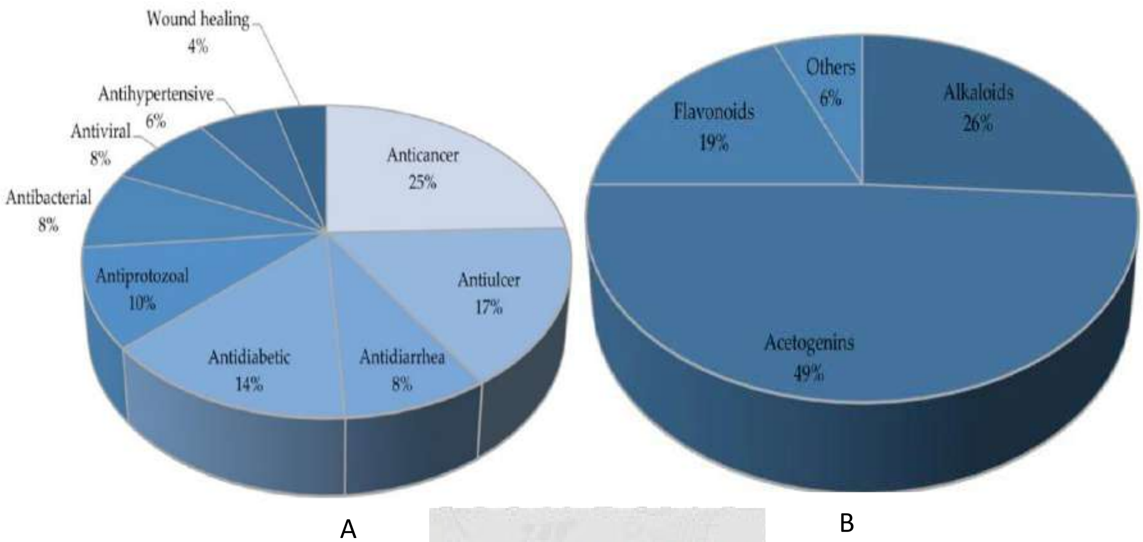

Fig 1.A.Different anti-filamentary action B. Different phytochemical compound present in soursop fruit

Table 1. The bioactive compound and essential functions of soursop plant extract.

Therapeutic attributes	Bioactive Components	Function
Anti-carcinogenic effect	1. Annonaceous, acetogenins 2. Quercetins 3. 2-phenyl-4h-1benzopyran-4-one	Chemopreventive properties lower the incidence of cancer.
Anticoagulant properties	1. Acetogenins 2. Alkaloids 3. Megastigmanes 4. Phenolics 5. Quercetins 6. Gallic acid	1. Improve immune response 2. Prevent inflammation 3. Antihemorrhagic effect
Antidiabetic effect	1.Total phenol flavonoid	1. Inhibitory effects on α-

	2. Antioxidant enzymes (superoxide dismutase (SOD), catalase, and nitrite oxide) 3.Caffeic acids 4.Procyanidins B_2 5.Catechins 6.Quercetins 7.Kaempferols	amylase and α-glucosidae. 2. Prevent the accumulation of glucose in the blood.
Anticholesterol properties	1.Flavonoids 2.Tannins 3.Alkaloids 4.Essential oils	1. Control fatty acid catalyze activity and lower LDL, TGs, as well as VLDL. 2. Reduce blood cholesterol.
Antioxidant properties	1.Alkaloids 2.Coumarins 3.Tannins 4.Flavonoids 5.Carbohydrates 6.Phenols 7.Terpenoids 8.Saponins	Free radical scavenge activity
Antihypertension and hyperuricemia properties	Extracted with n-butanol	Reduce the production of new uric acid and keep the blood pressure under control.
Induce apoptosis in cancer patients	Flavonoids	Potent inducer of apoptosis

SOURSOP ON CANCER

Extracts from soursop have demonstrated cytotoxic effects on various cancer cell lines. These studies suggest that soursop extracts may inhibit the growth of cancer cells and induce apoptosis (programmed cell death) in cancer cells reported by Orak *et al.*,2019 ans Agu *et al.*,2017. It has been suggested that *A. muricata* could serve as a natural product source for the development of drugs that induce apoptosis in cancer patients. The antioxidant properties of the Soursop fruit part extracts can also be measured by the ability to prevent degradation of deoxyribose via scavenging of hydroxyl (OH) radical and chelation of transition metals such as Fe^2 reported by Hasmila *et al.*,2019. The 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) scavenging activity of soursop extracts was determined by the method of Brand William et al. Human breast cancer cells (MCF-7); they used an ionic liquid extract of soursop extract (IL-GFE) and observed the cytokinetic behavior of the cells *Hadisaputri et al.,* 2021 . Many researchers concluded that the growth of tumor cells can be reduced by using ionic liquid extract of soursop of free radicals. The leaf water extract has inhibitory activity against colorectal cancer cells and does not affect normal cell growth.

Fig 2. The plant. flower, fruit and fruit cross section of Soursop

ANTIHEMORRHAGIC ACTION

Phenolic compounds can help with autoimmune illnesses, inflammatory bowel disease, and hemorrhoids. Phytochemical (Acetogenins, Alkaloids, and Megastigmanes) and phenolic compounds (quercetin and gallic acid) present in A.muricata are have antioxidant and antiinflammatory properties. Aqueous extract of the soursop leaf has a natural combination of bioactive components with a biogenesis (new blood vessel formation from a preexisting vessel) function is observed by Adefegha *et al.*,2015

Conclusion

Soursop is an exotic fruit with abundant nutritional properties. Its richness in phenolic compounds and high medicinal properties makes it economically utilized in pharma industries. These fruits are effectively utilized as a tasty fruit for cancer patients with its apoptosis action, Diabetic and Hypertension patients. Phytochemicals present in these plants are rich in phenols and flavonoids, especially acetogeneins are rich in anticarcinogenic properties. Bio active compounds present in this fruit have anti inflammatory properties and effective for haemorrhage. Therefore, soursop / Mullseetha is a natural medicine with good aroma and flavor. We have to created importance and health benefits to consumers. It leads a Healthy life.

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EFFECT OF STORAGE CONTAINERS ON SEED QUALITY OF DIFFERENT BARLEY VARIETIES UNDER AMBIENT CONDITIONS

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Abstract

The purpose of this experiment was to determine how well a variety of barley held up when kept at room temperature in two different kinds of containers: cotton and polythene. This research focuses on the following varieties: K409, K551, K560, K630, K1055, and K1149. For nine months the seeds were kept in two different bags made of cotton and polythene in an environment free of artificial atmospheric modification. Tests for germination rate, seedling length, seedling dry weight, seed vigour index I and seed vigour index II, moisture content of the seeds, crude protein percentage, fat percentage, and field emergence were conducted on the seeds while they were in storage. With the exception of fat percentage, all seed quality parameters were significantly affected by storage period, according to the investigation's results. When considering germination percentage (97.89%), seed vigour index II (30.79), crude protein percentage (12.57%), and fat percentage (5.04%), variety K409 yielded the best results. In terms of seed moisture content (9.52%), seedling length (25.28 cm), and overall performance, variety K551 stood out. Based on the seed vigour index I (2434.13), variety K560 was the most successful. With a seedling dry weight of 288.85 mg and an emergence rate of 88.5%, variety K603 was the most successful. During storage, the germination % and fat percentage were significantly affected by the various containers. The germinability and lipid content were both improved when stored in a polythene container. Aside from that, the quality of barley seeds kept at room temperature was unaffected by the containers. The weather changes that occur while the

goods are in storage are to blame for this. Because the monsoons occurred at the same time as storage and the store did not use any artificial atmospheric modification, the moisture content of the seeds steadily increased during the storage period.

Keywords: Barley, Seed quality, Storage containers, Cotton, Polythene, Germination

Introduction

Seed quality must be maintained to ensure agriculture's long-term sustainability and food safety. Barley, a staple cereal, affects global agriculture. Barley seeds must be preserved to remain alive and nutritious. This article examines how different storage containers affect barley seed quality in ambient circumstances. Seed quality refers to seed viability, vigour, and health. These traits affect seed germination and crop performance. High seed quality is essential for crop genetic integrity and optimal yields. Storage conditions, temperature, humidity, and containers greatly affect seed quality. Barley, Hordeum vulgare, is a cereal crop grown for animal feed, malting, and human consumption. Barley has been used to make beer, other distilled beverages, and healthy foods. Many civilisations' barley bread and soups and stews contain it. Traditional methods are used to make malt from barley grains. Barley is versatile.

This crop is growing in favour in tropical and temperate countries, where it is sown in winter and summer. Germination takes one to three days. Barley thrives in cold, but it's not winter-resistant. Winter wheats (Triticum aestivum), autumn rye (Secale cereale), and winter triticale (Triticosecale Wittm. ex A. Camus.) are more cold-resistant, but it can be grown as a winter crop in warmer places. Barley has a short growing season and little drought resistance. This plant is noted for its adaptability to many climates and soils. To maximise this crop's potential, barley seeds must be stored in good condition. If stored grain has insects, mites, mildew, and fungi, grain quality will suffer. Thus, monitoring and controlling these organisms in stored grain is crucial. Conditioning barley with aeration, unheated or natural grain drying, dry aeration, in-storage chilling, and heated air grain drying preserves its quality and allows it to be stored securely for longer. Choosing the correct seed storage containers might affect seed quality. Containers vary in their ability to control temperature, humidity, and protect seedlings. Common containers include jute bags, plastic bags, metal bins, and airtight containers. Despite their low cost, jute bags can let moisture in, affecting seed quality. Plastic bags protect against moisture, but they may not be impermeable, allowing pests in. Despite their longevity, metal bins can transfer heat, affecting seed temperature. However, airtight containers protect against moisture and pests, but their high cost may deter some growers. This experiment examined the seed quality of different barley cultivars stored in different containers in ambient circumstances to see how storage containers affect barley.

MATERIALS AND METHODS

Study area: The research was carried out on 6 different varieties of barley. They were stored in two separate types of bags, ie. porous and non-porous bags, for a period of 9 months during which tests were conducted regarding the quality of the seeds.

Experimental materials: Six different varieties of barley were collected, namely K-409, K-551, K-560, K-630, K-1055 and K-1149 from Department of Seed Science and Technology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. Two different types of bags ie., cotton bag (porous) and polythene bag (non-porous) were also collected from the Department of Seed Science and Technology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur.

Variety details:

K-409(husked): It is a 6-rowed hulled barley variety with a height of 94-100cm. The ears have a non-drooping attitude and the seeds have a waxy look. It is a pedigree of Jyoti X DL-65 and is used as a feed.

K-551(husked): It is a hulled 6-rowed barley with a height of 102-105cm. The ears have a non-drooping attitude and the seeds are non-waxy. It is a pedigree of P464 X Jyoti and is used for malting purposes.

K-560(husked): It is a hulled 6-rowed barley with a height of 100-110cm. The ears are non-drooping and the seeds do not have a waxy look. It is a pedigree of K404 X DL479 and is used for food purposes. It is resistant to lodging and rust.

K-603(husked): It is a hulled 6-rowed barley with a height of 100-105cm. The ears have a non-drooping attitude and the seeds are non-waxy. It is a pedigree of K257 X C138 and is used for food purposes.

K-1055(husked): It is a hulled variety of barley. It is tolerant to lodging and shattering and is resistant to foliar blight.

K-1149(hulless): It is a hulless variety used for food purposes. It is also used for malting purposes and gives a high malt yield (90%).

Observations recorded:

1. Germination %: Germination percentage of the barley seeds are calculated by following the rolled towel method of germination. In this method, 400 seeds in four replications each of 100 seeds are taken randomly from each variety and put for germination in the germination chamber. First count is taken on the 4th day and final count is taken on the 7th day. The number of normal seedlings, abnormal seedlings and fresh ungerminated seeds are taken and germination percentage is calculated.
2. Seedling length: On the day of final count, 10 normal seedlings are selected at random from each replication and their lengths are measured and recorded (in cm).
3. Seedling dry weight: 10 normal seedlings are selected at random from each replication. It was kept in an oven maintained at 100 ± 2 ^{0}C for 24 hours. After drying, the dried seedlings were kept for cooling in a desiccator (to avoid moisture gain) for 20-30 minutes and then the seedling dry weight was recorded on electronic balance in mg.
4. Seed vigour indices: For calculating seed vigour index, standard germination percentages of the seed were multiplied by total seedling length and seedling dry weight separately (Abdul Baki and Anderson, 1973).

   Seed vigour index I = Standard germination (%) × Total seedling length (cm)

   Seed vigour index II = Standard germination (%) × Seedling dry weight (gms)
5. Moisture %: Moisture % of each replication is calculated by following the hot air oven method. 5g of ground seed sample is taken from every replication which is then dried in the hot air oven at 100oC for 8hrs. Moisture content is determined by the formula:

   $$\frac{(\text{wt. of sample before drying} - \text{wt. of sample after drying}) \times 100}{\text{wt. of sample before drying}}$$
6. Fat %: To calculate fat percentage of barley seeds, the petroleum ether solvent extraction method was applied. 1g of ground barley seeds was weighed on a filter paper for every replication and wrapped in it. The filter paper pouches were stacked in a large beaker and filled with petroleum ether so that all of the samples were immersed. The liquid was then decanted after half an hour. The same procedure was repeated one more time with fresh petroleum ether after which the samples were dried and weighed. Total fat% was determined by the formula:

$$\frac{\text{(wt. of sample before extraction- wt. of sample after extraction) x 100}}{\text{wt. of sample before extraction}}$$

7. Crude protein %: Calculation of crude protein percentage is done by Kjeldahl method of protein determination. 1g of ground barley seeds was weighed on a filter paper for every replication and wrapped. In this method, after digestion of organic matter in concentrated sulphuric acid, the total nitrogen is converted to ammonium sulphate. Ammonia is formed and distilled into boric acid in alkaline conditions. The borate anions formed are titrated with standardised hydrochloric acid, by which is calculated the amount of nitrogen representing the amount of crude protein in the sample. Most proteins contain 16% of nitrogen. Therefore, the conversion factor is 6.25.

   Thus, crude protein = N% x 6.25

8. Field emergence test: Field emergence test is done to test whether the variety of the crop is able to adapt to natural field conditions. To carry out this test, 100 seeds of barley are counted from every replication and planted in distinct rows marked with tags. Germination rate is checked for 15 days.

RESULTS AND DISCUSSION

The observations on seed quality parameters namely germination percentage, seedling length, seedling dry weight, seedling vigour index I, seedling vigour index II, seed moisture content, crude protein percentage, fat percentage and field emergence were recorded at different stages of storage. Data for different observations were averaged and subjected to statistical analysis using factorial completely randomised design. The results of the interaction regarding varieties with storage time and containers are presented in two-way tables even in the cases of non-significant interaction effects. The results and mean sum of squares (MSS) are presented in the tables and also have been shown graphically.

Effect of storage containers on germination percentage of different varieties of barley.

Data related to effect of storage on germination percentage of different varieties of barley are presented in Table 1. It can be seen that there was a significant difference among the varieties and also the containers in terms of germination percentage. The comparison between time, varieties and containers (ie. Time x Varieties x Container) also showed statistical significance.

The highest germination percentage was recorded for the variety K409 (97.89%) while the least germination percentage was recorded in K1149 (93.37%). The cotton container

(95.06%) had lower germination percentage than the polythene container (96.42%) which is due to the fact that polythene containers are impervious to temperature and humidity fluctuations as opposed to cotton containers, being porous, which are greatly affected by environmental fluctuations especially during rainy periods.

These findings were in conformity with the results of Woods and Favier (1994) in barley, White *et al.* (1999) in barley, Armitage *et al.* (2002) in barley, Patil, PR (2013) in hybrid paddy, Surayavanshi, UB (2013) in soybeans, Sampath (2017) in rice, Wakode, SK (2017) in soybeans and Obtute et al (2018) in soybeans.

Table 1: Effect of storage containers on germination percentage of different varieties of barley.

<u>Varieties x Container Mean</u>

	K409	K551	K560	K603	K1055	K1149	Mean
Cotton	97.48	94.25	94.85	97.07	94.81	91.92	95.06
Polythene	98.29	94.33	96.81	97.33	97.00	94.81	96.42
Mean	97.88	94.29	95.83	97.2	95.90	93.36	

<u>Varieties (V) and Container (P)</u>

	Varieties	Container	V*P
Std. error	0.270	0.156	0.382
C.D.	2.98	1.36	2.74

Effect of storage containers on seedling length of different varieties of barley.

Data obtained from effect of storage on seedling length of different varieties of barley is clearly shown in Table 2. It is seen that there is statistically significant difference in the seedling lengths among the different varieties. The containers however were shown to have no significant effect during the storage period. The comparisons were also not significant.

The longest seedling length 25.28cm was recorded in K551 and the shortest was that of K1149 (23.18cm). The containers having no significant effect on seedling length is due to the fact that although seed germination was affected the overall vigour of the seeds were not impacted significantly throughout the duration of the storage period.

The results of Naik (2006) in sesame, Choudhury *et al*. (2011) in rice, Surayavanshi (2013) in soybeans, Leelavathi (2017) in green gram and Sampath (2017) in rice were similar to the findings of this investigation.

Table 2: Effect of storage containers on seedling length of different varieties of barley.

Varieties x Container Mean

	K409	K551	K560	K603	K1055	K1149	Mean
Cotton	23.61	25.25	25.18	24.82	24.39	22.95	24.36
Polythene	24.15	25.28	25.16	23.28	24.34	23.41	24.27
Mean	23.88	25.26	25.17	24.05	24.36	23.18	

Varieties (V) and Container (P)

	Varieties	Container	V*P
Std. error	0.332	0.185	0.453
C.D.	1.82	NS	NS

Effect of storage containers on seedling dry weight of different varieties of barley.

The data obtained from effect of storage on seedling dry weight of different varieties of barley is shown in Table 3. The seedling dry weights of different varieties of barley show significant difference among the varieties. The containers however showed no significant effect during the storage period and the comparisons were also not significant.

According to Table 3, K603 (288.85mg) has the highest seedling dry weight and K1149 (217.17mg) has recorded the lowest. Reasoning similar to seedling length can be given in case of seedling dry weight not being affected while being stored in different containers.

These findings were comparable to the results of Naik, JK (2006) in sesame, Surayavanshi, UB (2013) in soybeans, Polat, H.E. (2015) in barley and maize, Leelavathi, M (2017) in green gram and Sampath, CVMS (2017) in rice.

Table 3: Effect of storage containers on seedling dry weight of different varieties of barley.

Varieties x Container Mean

	K409	K551	K560	K603	K1055	K1149	Mean
Cotton	267.37	274.51	277.77	288.85	236.00	214.00	259.75
Polythene	273.29	283.63	274.44	288.85	228.66	220.33	261.53
Mean	270.33	279.07	276.10	288.85	232.33	217.16	

Varieties (V) and Container (P)

	Varieties	Container	V*P
Std. error	2.721	1.571	3.848
C.D.	33.04	NS	NS

Effect of storage containers on seed vigour index I of different varieties of barley.

Results obtained from effect of storage on seed vigour index I (germination x seedling length) of different varieties of barley can be seen in Table 4. Seed vigour index I, which resulted by multiplying germination percentage with seedling length, has shown statistical significance among the varieties. No significant effect was shown by the containers during the storage period. The comparisons of varieties x containers and time x varieties x containers were also not significant.

The variety K560 (2434.13) recorded the highest seed vigour index I and K1149 (2119.9) recorded the lowest. From previous results, it was determined that storing the barley seeds in different containers had a significant effect on seed germination while there were no such effects for seedling length. Thus, the non-significance of the containers on seed vigour index I, being a product of seed germination percentage and seedling length, is indirectly determined by seedling length in this case.

The resulting findings were in accordance with the work of Jyothi, KU (2004) in chillies, Nambiar, PKM (2006) in soybeans, Choudhury *et al*. (2011) in rice, Patil, PR (2013) in hybrid paddy, Wani et al (2014) in maize, Bortey et al (2016) in cowpea, Pameri et al (2016) in rice, Sampath, CVMS (2017) in rice and Wakode, SK (2017) in soybeans.

Table 4: Effect of storage containers on seed vigour index I of different varieties of barley.

Varieties x Container Mean

	K409	K551	K560	K603	K1055	K1149	Mean
Cotton	2318.66	2319.04	2413.63	2383.36	2287.04	2063.24	2295.82
Polythene	2385.58	2323.19	2454.64	2285.11	2322.23	2176.57	2324.55
Mean	2352.12	2321.11	2434.13	2334.23	2304.63	2119.90	

Varieties (V) and Container (P)

	Varieties	Container	V*P
Std. error	29.19	16.85	41.29
C.D.	229.34	NS	NS

Effect of storage containers on seed vigour index II of different varieties of barley.

The data on effect of storage on seed vigour index II (germination x seedling dry weight) of different varieties of barley is shown in Table 5. Seed vigour index II, calculated by multiplying germination percentage and seedling dry weight (in g), has shown significant difference among the varieties. The containers had no significant effect on seed vigour index II throughout the period of storage. Also, all the comparisons between time, varieties and containers showed no statistical significance.

The highest seed vigour index II was recorded for variety K409 (30.79) and the lowest for K1149 (20.75). The non-significance of the containers on seed vigour index II, being a product of seed germination percentage and seedling dry weight, is indirectly determined by seedling dry weight in this case, as it was already determined non-significant in previous results presented above.

The work of Jyothi, KU (2004) in chillies, Nambiar, PKM (2006) in soybeans, Choudhury *et al*. (2011) in rice, Patil, PR (2013) in hybrid paddy, Wani et al (2014) in maize, Bortey et al (2016) in cowpea, Pameri et al (2016) in rice, Sampath, CVMS (2017) in rice and Wakode, SK (2017) in soybeans had findings that were in accordance with the findings of this investigation.

Table 5: Effect of storage containers on seed vigour index II of different varieties of barley.

Varieties x Container Mean

	K409	K551	K560	K603	K1055	K1149	Mean
Cotton	34.82	25.29	26.66	28.16	22.66	20.39	26.33
Polythene	26.75	26.18	26.34	27.69	23.61	21.11	25.28
Mean	30.78	25.47	26.5	27.92	23.13	20.75	

Varieties (V) and Container (P)

	Varieties	Container	V*P
Std. error	1.81	1.04	2.56
C.D.	6.91	NS	NS

Effect of storage containers on seed moisture content of different varieties of barley.

Data related to effect of storage on seed moisture content of different varieties of barley can be seen in Table 6. It can be seen that there is significant difference regarding seed moisture content among the varieties. No significant effect was shown by the containers during the storage period. The comparisons of varieties x containers and time x varieties x containers were also not significant.

Among the varieties, K1149 (10.31%) has the highest seed moisture content and K551 (9.72%) has the lowest seed moisture content. These results were similar with the findings of Lund *et al.* (1971), White *et al.* (1999) in barley, Al-Yahya, S (2001) in wheat, Armitage *et al.* (2002) in barley, Jyothi, KU (2004) in chillies, Malaker et al (2008) in wheat, Surayavanshi, UB (2013) in soybeans, Tripathi and Lawande (2014) in onion and Sampath, CVMS (2017) in rice.

Table 6: Effect of storage containers on seed moisture content of different varieties of barley.

Varieties x Container Mean

	K409	K551	K560	K603	K1055	K1149	Mean
Cotton	10.19	9.7	9.99	9.97	10.01	10.44	10.05
Polythene	10.32	9.74	9.95	10.09	9.93	10.17	10.04
Mean	10.26	9.72	9.97	10.03	9.97	10.31	

Varieties (V) and Container (P)

	Varieties	Container	V*P
Std. error	0.075	0.054	0.109
C.D.	0.47	NS	NS

Effect of storage containers on field emergence of different varieties of barley.

Field emergence was recorded once after the storage period was over. The data for field emergence can be seen in Table 9. The data shows that there was significant difference in the field emergence of different varieties of barley although no significant effect was recorded regarding the containers. The comparison between the varieties and containers also was not significant. Variety K603 showed highest field emergence percentage (88.5%) and K1149 showed the lowest (75.3%).

The resulting findings were in accordance with the results of Jha, KK (2007) in groundnut and Sampath, CVMS (2017) in rice.

Table 9: Effect of storage containers on field emergence of different varieties of barley.

Varieties x Container Mean

	Cotton	Polythene	Mean
K409	88.66	88	86.33
K551	78.33	79.33	78.83
K560	83.66	85.33	84.5
K603	88.33	88.66	88.5
K1055	82	85	83.5
K1149	73.66	77	75.33
Mean	81.78	83.89	

Varieties (V) and Container (P)

	Varieties	Container	V*P
Std. error	1.36	0.79	1.93
C.D.	7.8	NS	NS

SUMMARY AND CONCLUSION

A gist of results obtained from the present investigation are summarized as below:

- Variety K409 gave the highest results in terms of germination percentage and seed vigour index II. Variety K551 had the best results in terms of seedling length and seed moisture content. Variety K560 performed best according to seed vigour index I. Variety K603 performed the best in terms of seedling dry weight and field emergence.
- The different containers had a significant effect on germination percentage during the storage period. Polythene container proved to be more favourable for better germinability during storage which indicates that polythene containers have better keeping quality than cotton containers. Other than that, containers had no significant effect on the storability of barley seeds in ambient conditions. This is due to the vigour of the seeds not being affected by the fluctuation in weather conditions during storage.

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UNDERUTILIZED FRUIT CROPS AND THEIR IMPORTANCE

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Introduction

Fruits have wide sources of nutrients, minerals,vitamins and fibers. They are low in calories and naturally sweet. India is considered as a larger producer of fruits in the world. Commercially available major fruits are cultivated in wide range and consumed, whereas forget the nutrient benefits which is available in minor fruits. It have an integral component of the Indian traditional food system, consumed by many rural and tribal communities. It is rich in nutraceuticals and bioactive compounds and also may provide an efficient way to combat malnutrition with low agricultural input. Here we discuss about the minor fruits and their health benefits.

Jamun – *Syzygium cumini*

Order- Myrtales

Family - Myrtacea

Genus - *Syzygium*

Species –*cumini*

Jamun is a perennial crop originated from Indian subcontinents and various regions of southeast Asia. The other names of jamun are Indian blackberry, puple plum, Java plum or *Naavar palam* in Tamil. It requires annual rainfall and temperature upto 350-500 mm and 25-27 degree celcius respectively. Further it grown well under semiarid and subtropical regions and also in problemetic soils like calcareous, sodic soils and marshy areas.

Nutrient composition

S.No.	Nutrient composition	Per 100 g
1.	Moisture (%)	85.25
2.	TSS (%)	9.5
3.	Crude fibre(g)	0.85
4.	CHO (g)	11.24
5.	Protein	0.87
6.	Fat	0.54
7.	Vitamin C (mg)	151.51
8.	Beta carotene (mg)	112.38
9.	Sodium (mg)	28.0
10.	Potassium (mg)	285.0

Health benefits of Jamun

- Boost immune system
- Proper digestion
- Increase haemoglobin count
- Act as a blood purifier.

Ber – *Ziziphus mauritiana*

Order- Rosales

Family - Rhamnaceae

Genus - *Ziziphus*

Species –*mauritiana*

Ber is indigenous to India and also known as poor man fruit. Sandy loam soil is suitable for cultivation with an annual rainfall of 400mm and grown well under arid and semiarid regions. It can tolerate both salinity and alkalinity conditions. The other common names of ber are Indian plum, Indian jujube and *Ilandhai palam* in Tamil.

Nutrient composition

S.No.	Nutrient composition	Per 100 g
1.	Fat	0.2
2.	CHO (g)	20
3.	Sodium (mg)	3
4.	Protein (g)	1.2
5.	Vitamin C (%)	115
6.	Calcium (%)	2
7.	Vitamin B6 (%)	5
8.	Magnesium (%)	2
9.	Iron (%)	2
10.	Potassium(mg)	250

Health benefits of Ber

- Boost immunity
- Manage your blood glucose levels
- Effective for weight loss
- Quick healing of wounds and combats cancer

Custard Apple – *Annona squamosa L.*

Order- Magnoliales

Family - Annonaceae

Genus – *Annona*

Species – *squamosa*

Its origin is Tropical America, crop requires warm and humid climate with mild winters. The crop is very hardy, medium in growth and decidious in nature. The most common names used for custard apple is Ox heart, bullock heart, sugar apple and *Sitapalam* in Tamil.

Nutrient composition

S.No.	Nutrient composition	Per 100 g
1.	CHO (mg)	23.71

2.	Calcium (mg)	22
3.	Vitamin B6 (mg)	0.2
4.	Magnesium (mg)	42
5.	Iron (mg)	0.7
6.	Niacin (mg)	0.5-0.8
7.	Potassium(mg)	382.1

Health benefits of Custard apple

- Promote digestion
- Anticancer properties
- Support immunity
- Improves eye health (Antioxidant luten)
- Prevent blood pressure (K and Mg)
- Regulate your mood (Vitamin B6)

Jungle jalebi – *Pithecellobium dulce*

Order- Fabales

Family - Fabaceae

Genus - *Pithecellobium*

Species –*dulce*

It can survive in drylands and considered as a drought tolerant crop. It is indigenous to Central America and Mexico Madras Thorn, Monkey pod, Manila tamarind and *Kodukkapuli* in Tamil. It can survive in drylands and considered as a drought tolerant crop.

Nutrient composition

S.No.	Nutrient composition	Per 100 g
1.	CHO (g)	76.87
2.	Protein (g)	12.4
3.	Calcium (g)	0.01
4.	Iron (g)	0.005
5.	Potassium(g)	0.2
6.	Phosphorus (g)	0.04

Health benefits of Jungle jalebi

- Improves immune system
- Fortifies bones and muscles
- Manage diabetes
- weight loss
- Relieves anxiety and depression.

Conclusion

The minor fruits are grown in low fertile soils, resistant to pest and diseases and also not much care is needed for cultivation. Hence in this aspect we focus on promote and cultivating minor fruits which is available in wild, semiwild and semidomesticated conditions with adverse genetic diversity. Along with this, care should be given for post- harvest processing of this underutilized minor fruits give new dimensions in innovative food designing. The central and state government encourage farmers to grow minor fruits for preserving genetic diversity, preventing extinction and safeguarding plant wealth.

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ENTOMOPHAGY FOR NUTRITIONAL SECURITY

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Introduction

Food Security Act (2013) states that, in India everyone should get sufficient quantity of nutritious food for the whole year. This is rather jeopardized due to increase in human population and decrease in crop productivity and food availability. The natural factors responsible for food insecurity such as climate change, soil health, imbalance of plant nutrient, pests and disease incidence, and manmade situations such as increased food prices, non-availability of foods, lack of purchasing power of consumers, disparity in food distribution etc,. To overcome this quandary searching for new available sources to substitute food can be a viable and obligatory step. For improving food supply through new viable technologies on a large scale would take longer time. As a global responsibility, at least for member countries, the Food and Agriculture Organization (FAO) of the United Nations took an initiative to create a policy and proposed the programme of feeding people with alternative sources including insects. Insects are environmentally friendly, as they can recycle waste, require little food and water for their growth, and have a rapid growth rate. For all these reasons, in recent years, entomophagy has reached global attention.

Entomophagy

Insects have played an important part in the history of human nutrition in Africa, Europe, Asia, and Latin America. Entomophagy is a not newly evolved concept, people are practicing from ancient times. The term Entomophagy (from the Greek words entomon, "insect" and phagein, "to eat") refers to the process of eating insects as food.

Diversity of Edible Insects in India

Over 1900 species of edible insects in 300 ethnic groups in 113 countries worldwide have been recorded by various authors to be part of human diet (MacEvilly, 2000). According to Chakravorty *et al*. (2011) 298 edible insects have been reported belonging to order coleopteran (34%), orthoptera (24%), hemiptera (17%), hymenoptera (10%), odonata (8%), lepidoptera (4%), isoptera (2%) and ephemeroptera (1%) and also stated insect diversity in Arunachal Pradesh (158 species), Manipur and Nagaland (41 species each), Assam (38 species), Meghalaya (16 species), Kerala (5 species) and Karnataka, Tamil Nadu, Odisha and Madhya Pradesh (1 species each).

Nutritional Values of Edible Insects

The insects have been well recognized worldwide as natural renewable resource nutritious food since insects provide carbohydrates, proteins, fats, essential fatty acids, minerals, vitamins, fibre and micronutrients.

Studies on the nutritional composition of edible insects should meet internationally recognized standards. The nutritional values of edible insects are highly variable because of its richness in species diversity. Even within same insect species also differences exist in nutritional values depending on the stage of the insects (egg, larvae, pupa and adult in case of holometabolous insects and egg, nymph and adults of hemimetabolous insects) and also the variation in nutrient composition is due to different analytical methodologies, the heterogeneity existing between insects from different environments and different rearing and storage conditions. The international network of food data systems (FAO INFOODS) has recently published a database on food composition and in version 4.0 a total of 471 edible insects, with different methods of preparation.

In India, insect eggs, larvae/nymphs, pupae and adults are consumed probably because there is vast difference in the content of nutrients as per insect development period. Consumption of crickets, termites, grasshoppers and caterpillars yields a high energy value. Content of protein is significantly higher than or equal to animal foods such as, chicken, pork, eggs, beef or lamb. When five insects were compared for nutritive value, high protein content was found in dragon fly, *Crocothermis servilla* (Drury) larva (70.48%), short horned grasshopper, *Oxyahyla hyla* Serville adult (64.67%), surface grasshopper, *Oedaleus abruptus* (Thunberg) adult (60.00%) and eri silkworm, *Samiari cini* (Drury) pupa (71.9%).

Table 1. Commonly explored major edible insect species documented from India

Method of processing	Insect species	Order: Family	Insect life stage(s)	State
Baked	*Apis cerana indica*	Hymenoptera: Apidae	Egg, larva, pupa	Assam
	Antheraea assamensis	Lepidoptera: Saturnidae	Pupa	Assam
	Oecophylla smaragdina	Hymenoptera: Formicidae	Egg, adult	Assam
	Rhynchophorus phoenicis	Coleoptera: Curculionidae	Larva	Assam
	Rhynchophorus ferrugineus	Coleoptera: Curculionidae	Larva	Assam
Cooked	*Pentatomid* sp.	Hemiptera: Pentatomidae	Adult	Arunachal Pradesh
	Locusta sp.	Orthoptera: Acrididae	Adult	Arunachal Pradesh
Cooked + baked	*Polistes stigmata*	Hymenoptera: Vespidae	Egg, larva, pupa	Assam
	Samia ricini	Lepidoptera: Saturnidae	Larva, pupa	Assam
	Myrmica rubra	Hymenoptera: Formicidae	Larva, pupa	Assam
Dry/deep fried	*Reticulitermes flavipes*	Isoptera: Rhinotermitidae	Adult	Assam
	Dihammu scervinus	Coleoptera: Cerambycidae	Larva	Assam
	Meligethes aeneus	Coleoptera: Nitidulidae	Larva	Assam
	Batocera	Coleoptera:	Larva	Assam

	rufomaculata	Cerambycidae		
	Okanagan sp.	Diptera: Asilidae	Adult	Assam
Dry/deep fried + baked	*Megasoma elephas*	Coleoptera: Scarabaeidae	Larva	Assam
	Apis dorsata	Hymenoptera: Apidae	Larva, pupa	Assam
	Apis cerana indica	Hymenoptera: Apidae	Larva, pupa	Assam
	Apis florea	Hymenoptera: Apidae	Larva, pupa	Assam
Deep fried + roasted	*Mantis religiosa*	Orthoptera: Mantidae	Nymph, adult	Assam
	Melanopus sp.	Orthoptera: Acrididae	Adult	Assam
Raw/fresh	*Aeshna mixta*	Odonata: Aeshnidae	Nymph, adult	Assam
	Neurothemis fluctuans	Odonata: Libellulidae	Nymph, adult	Assam
	Apis dorsata	Hymenoptera: Apidae	Larva (hive)	Arunachal Pradesh
	Apis cerana indica	Hymenoptera: Apidae	Larva (hive)	Arunachal Pradesh
	Vespa mandarinia	Hymenoptera: Vespidae	Larva	Arunachal Pradesh
Roasted	*Schizodactylus monstrosus*	Orthoptera: Gryllidae	Nymph, adult	Assam
	Gryllus campestris	Orthoptera: Gryllidae	Nymph, adult	Assam
	Gryllotalpa africana	Orthoptera: Gryllotalpidae	Nymph, adult	Assam

	Odontolabis cuvera	Coleoptera: Lucanidae	Adult	Assam
	Lucanus elsphus	Coleoptera: Curculionidae	Adult	Assam
	Cyrtotrachelus buqueti	Coleoptera: Dynastidae	Larva	Arunachal Pradesh
	Eurytrachelus titan	Odonata: Libellulidae	Adult	Assam
	Libellula carolina	Orthoptera: Acrididae	Adult	Assam
	Schistocerca gregaria	Hemiptera: Belostomatidae	Nymph, adult	Assam
	Belostoma indicus	Hymenoptera: Vespidae	Adult	Arunachal Pradesh
	Vespa tropica	Hymenoptera: Vespidae	Larva	Arunachal Pradesh
	Vespa bicolor	Hymenoptera: Vespidae	Larva	Arunachal Pradesh
	Polistes sp.	Hymenoptera: Vespidae	Larva	Arunachal Pradesh

Table 2. Nutritional composition of commonly exploited edible insect species of India

Nutrient (%)	*Brachytrupes orientalis*	*Oxyahyla hyla*	*Oedaleus abruptus*	*Aspongopus nepalensis*	*Crocothermis sevilla*
Carbohydrates	15.18	28.17	30.00	-	1.18
Crude protein	65.74	64.67	60.00	10.60	70.48
Fat	6.33	2.18	15.00	38.35	4.93
Crude fibre	8.75	9.23	-	33.47	9.62
Ash	-	-	5.00	2.10	1.34
Calcium	0.24	-	5.00*	0.12	86.5

Potassium	-	-	10.35	26.80	-
Sodium	-	-	1.02	14.10	-
Phosphorus	-	1.75	0.075	-	-
Magnesium	0.54	0.084	6.00*	-	37.00
Zinc	2.10	0.017	2.50*	9.30	-

*mg/kg

Conclusion

With increasing awareness of nutritional security insects were used as a source of nutritional food and will be continue for future generations too. Insects, because of their high reproduction rate, high energy conversion rate, high survival capacity, short life period and short space requirements will provide one of the viable alternative opportunities for food security. In future, information on nutritional aspects can effectively be used for better utilization of insects to combat malnutrition and undernourishment with insect protein. In this perspective, regulations established by FSSAI are to be rigorously respected in the production and processing of edible insects. Eventually, International, national and public private institutions have to be work together and develop new technologies related to entomophagy.

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ROLE OF GAUSHALAS IN CONSERVATION OF INDIGENOUS CATTLE

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Abstract

Gaushalas, or cow shelters, have emerged as critical institutions in the conservation of indigenous cattle breeds in India, safeguarding them from extinction while promoting their cultural, economic, and ecological importance. Indigenous cattle, known for their resilience, adaptability, and the production of milk, face threats due to the growing preference for exotic breeds that yield higher milk. Gaushalas work to reverse this trend by engaging in selective breeding, and supporting the use of cow-derived products in organic farming and traditional medicine. They collaborate with government programs like the Rashtriya Gokul Mission to enhance their efforts. Despite the challenges of overcrowding, limited resources, and funding, gaushalas contribute to the preservation of valuable genetic traits, raise awareness about the significance of native breeds, and promote sustainable economic models through the sale of by-products like cow dung and urine. The continued conservation of indigenous cattle is essential for maintaining India's agricultural biodiversity, cultural heritage, and the sustainability of rural economies.

Keywords: Gaushalas, Indigenous cattle, Conservation

Introduction

India is having a vast reservoir of cattle genetic resources not only in terms of population but also in genetic diversity represented by 53 recognized indigenous cattle breeds. As per the 20th Livestock Census, India is having about 192.49 million cattle population, 73.82 % i.e. 142.11 million are indigenous/non descript and 26.19 % are exotic/cross bred animals. About

0.8% of increase in the total cattle population of the country was registered as compared to previous census. There is a decline of 6 % in the total Indigenous (both descript and non-descript) Cattle population over the previous census. However, the pace of decline of Indigenous Cattle population during 2012-2019 is much lesser as compared to 2007-12 which was about 9%. The major factors for decrease in indigenous cattle population are attributed to uneconomical returns due to low productivity and replacement of draft power in agriculture by mechanization. As a result, cattle (particularly unproductive, old and stray) find shelter in the Gaushalas instead of individual households. The Gaushala movement in India is synonymous with the protection of cows and cattle wealth of the country. During the 1st five year plan there were nearly 3000 Gaushalas spread over the whole country. As per statistics by the Animal Welfare Board of India (AWBI), India has 1837 registered Gaushalas.

At present India is having more than 7676 Gaushalas including unregistered, spread over in its length and breadth. Several Gaushalas in the country have followed innovative methods for raising additional income through various income generation activities viz. enhanced utilization of bull power for rural activities and electricity generation, production of young bulls for export to other States, production of gobargas, and production of Panchagavya, vermicompost and bio-pesticide for use in natural and organic agriculture. Large scale practice of such value additions may lead to transformation of Gaushalas to play an additional but pivotal role in conservation of indigenous breeds of cattle. Nevertheless, effective management of Gaushalas in the present context is posing a serious challenge to the Gaushalas, due to paucity of funds, inadequate financial aid from governments, inadequate fodder availability, non-availability of veterinary services, poor infrastructure facilities and poor management, as some of the chronic problems faced by Gaushalas. Besides this, lack of authentic database of Gaushala inventory, adds much to the vows of the Gaushala managers, policy planners, researchers, development agencies and farmers/livestock keepers as they need the primary data on Gaushala resources for evolving realistic strategies to improve the functioning of Gaushalas and thereby ensuring cattle welfare.

Key Roles of Gaushalas in Conservation of indigenous Cattle:

1. **Protection of Indigenous Breeds**:
   - Gaushalas provide a safe haven for indigenous cattle, protecting them from being slaughtered or abandoned due to their lower milk productivity compared to exotic breeds

- They play a vital role in conserving over 40 recognized indigenous cattle breeds, including Gir, Sahiwal, Red Sindhi, and Tharparkar, which are adapted to the Indian climate and environment.

2. **Breeding Programs**:
   - Many gaushalas actively engage in selective breeding programs to maintain and improve the genetic pool of indigenous breeds.
   - They collaborate with veterinary institutes and agricultural universities to promote the breeding of high-quality indigenous cattle. These programs help in preserving valuable traits such as disease resistance, heat tolerance, and the ability to thrive on low-input feed.
3. **Research and Development**:
   - Some gaushalas are involved in research activities to explore the medicinal properties of cow-derived products such as cow urine and dung (known as **Panchgavya** products), which are believed to have Ayurvedic and organic farming applications.
   - They support the development of bio-fertilizers and organic pesticides, promoting sustainable agricultural practices and reducing dependence on chemical fertilizers.
4. **Economic Sustainability**:
   - Gaushalas help in generating income from indigenous cattle through the sale of cow dung, urine, and milk. These by-products are used in organic farming, biogas production, and as inputs in traditional medicine and cosmetics.
   - By promoting the use of these by-products, gaushalas ensure that indigenous cattle remain economically sustainable even when their milk productivity declines.
5. **Awareness and Cultural Significance**:
   - Gaushalas often serve as centers of education, spreading awareness about the importance of conserving indigenous cattle and their role in maintaining India's agricultural biodiversity.
   - Cows have deep religious and cultural significance in India, especially within Hinduism. Gaushalas help in keeping these cultural practices alive by promoting the reverence for cows and the associated traditional practices.

6. **Partnership with Government and NGOs**:
   - Gaushalas frequently collaborate with government bodies, such as the National Dairy Development Board (NDDB) and the Rashtriya Gokul Mission (RGM), to access funds, technical assistance, and support for their conservation efforts.
   - NGOs and civil society organizations also work with gaushalas to enhance their outreach, making conservation efforts more organized and impactful.

According to Rashtriya Gokul Mission, (2014) development of Integrated Indigenous Cattle Centers – "Gaushalas" envisages the following objective of conservation and development of indigenous bovine breeds in the country:

1. To act as a nucleus herd for *in-situ* conservation of indigenous breeds.
2. Proper shelter, maintenance and feeding for stray and abandoned animals.
3. Proper health care and treatment of injured and sick animals.
4. To enhance productivity of indigenous breeds and increase economic returns from animal products in a sustainable manner.
5. To promote green power and eco technology.
6. To propagate high genetic merit bulls of indigenous breeds.
7. To optimize modern farm management practices and promote common resource management.

According to the Cow Protection Bill, 2017 of Government of India the following mandates are envisaged:

1. To ensure stabilization of the cow population in the country and formulate a comprehensive policy for this purpose.
2. Undertake a baseline study to collect data about cow population and to formulate a Qualitative Cow Dignity Index.
3. Formulate schemes to provide for healthy *Bos indicus* cows and calves.
4. Provide for funds to help incentivize adoption of cow and setting up Gaushalas.
5. Recommend to the Central Government, deterrent penalties including death penalty, to those who commit offences against cows and break the policies framed by the Authority.
6. Frame syllabus for awareness about importance of cow protection and development all over the country.

7. Conduct awareness campaigns about medical imperatives for improving health of *Bosindicus* cows and progeny.
8. Promote the manufacturing of fertilizers and insecticides with the use of gobar and gomutra, ark, neem and tulsi;

Role of Gaushalas in conserving the Cattle Wealth

The population of indigenous cattle of the country has been decreasing over the years. But due to introduction of mechanized farming operations and indiscriminate cross breeding programmes for increasing milk production, many farmers are forced to abandon such indigenous unproductive cattle. This has led to extra burden on the farmers' to take care of feeding, breeding and healthcare needs of the cattle. All these events have led to serious problem of stray cattle in India. The cause may be the fodder and feed which they want to save for productive cattle or young heifers and calves. A few fore front Gaushalas are striving to maintain nucleus herd for *in-situ* conservation of indigenous purebred cows and produce quality males so as to enhance productivity of indigenous breeds and increase economic returns from animal products in a sustainable manner. In this direction, the Govt. of India under Rashtriya Gokul Mission (2014) emphasized special attention to develop and conserve the indigenous bovine breeds. The mission envisages establishment of integrated cattle development center "Gokul Grams" and "Gaushalas" to develop indigenous cattle breeds.

In India, cow slaughter is prohibited in many states owing to religious reasons. Both the slaughter of cows and the sale of beef are punishable and non-bailable offenses in some states that demand rigorous fine and imprisonment for five to ten years. The factors such as abandoning unproductive cattle, prohibiting beef and rigorous penalties on transportation cattle outside could lead to increase in stray cattle population. Currently there are more than 5 million stray cattle in India. They hinder people's ordinary life by causing traffic jams and being one of the main causes of road accidents. They are also occupying parks and residential areas, defecating on the highways and clogging dung sewers. They also lead to crop losses by grazing farmers' fields. Farmers therefore incur huge fencing costs. The main reasons are due to in adequate space and funds with the Gaushalas and lack of public cooperation.

Animal Welfare in Gaushalas:

According to OIE (World Organization for Animal Health) Animal Welfare means 'how an animal is coping with the conditions in which it lives'. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behavior, and if it is not suffering from unpleasant states such as pain, fear, and distress.

The cattle should enjoy the following mandatory freedom in the Gaushalas:

1. Freedom from hunger and thirst.
2. Freedom from pain, injury and disease.
3. Freedom from fear and distress.
4. Freedom from discomfort.
5. Freedom to express normal pattern of behavior.

Cow is considered sacred by a majority of the population in India. Animal welfare in India has gained a huge significance with respect to cow's welfare and protection. There are certain amendments, laws and institution developed to address cow welfare and protection. The Animal Welfare Board of India (AWBI), established in 1962 under Section 4 of the Prevention of Cruelty to Animals Act, 1960 is an apex and statutory advisory body under *Ministry* of Environment and Forests for formulating animal welfare laws and policies that promotes animal welfare in the country. It also provides financial grants to Gaushalas registered under AWBI and provide advice to the Government of India on animal welfare issues. Gaushala being the State subject mostly is governed by their respective State Goseva Ayogs. The Gaushalas in the State acquire registration under different provisions viz., Societies Registration Act, Gaushala Act etc., thus confirming to the animal welfare bylaws of their respective State. According to, The Indigenous Cow Protection Board Bill, 2017 it provides legal constitutional rights for the protection of indigenous cow and its progeny. To safeguard the interest of different communities, the Supreme Court had included the laws against cow slaughter as Directive Principle of State Policy. This means that States have the power to enforce independent policy for the matter which will be valid within the State only. All these have led to the empowerment of animal welfare boards both in Centre and State to take action against illegal smuggling and slaughtering of cows, thereby protecting our cows from the vagaries of external threat in our country.

Major Challenges faced by Gaushalas:

Funding and Resources: Many gaushalas struggle with inadequate funding, limiting their ability to care for a large number of cattle. They often rely on donations, government grants, and charity for their operations.

Overcrowding: Overcrowding is a major challenge, especially in urban gaushalas. The rising number of abandoned cattle often exceeds the shelter's capacity to provide adequate food and healthcare.

Low Productivity of Indigenous Breeds: Indigenous cattle generally have lower milk yields compared to exotic breeds, which can discourage farmers from maintaining them unless supported by subsidies or alternative revenue streams.

Lack of Scientific Support: While many gaushalas engage in traditional practices, they often lack access to modern veterinary care, scientific breeding techniques, and sustainable management practices.

Suggestions for improved performance of Gaushalas:

The major constraints experienced in Gaushalas were; 'inferior quality of bulls', 'limited access to veterinary services', and 'inadequate funds/capital and training' for effective management. The identified perceived important factors affecting the performance of Gaushalas were; 'regular financial support', 'good infrastructural facilities' and 'Government support for training and development'. Hence it is a high time to sensitize and train the Gaushalas management about the GMPs through adequate extension, policy and financial support for holistic development of Gaushalas in our country.

Conclusion

Gaushalas play a vital role in the conservation of indigenous cattle by preserving genetic diversity, promoting sustainable agriculture, and safeguarding the cultural significance of cows in India. With proper support, scientific backing, and funding, gaushalas can contribute significantly to the long-term conservation and promotion of native cattle breeds, ensuring both their survival and economic utility in India's agricultural landscape.

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IMPORTANCE OF GOOD DAIRY MANAGEMENT PRACTICES (GDMPs) IN DAIRY CATTLE PRODUCTION SYSTEM

Article ID: AG-VO4-I10-74

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Abstract

Good Dairy Management Practices (GDMPs) are vital to enhancing the efficiency, productivity, and sustainability of dairy cattle production. They encompass a range of best practices, including proper feeding, disease prevention, reproductive management, milking hygiene, and waste management. By focusing on the health and welfare of cattle, GDMPs improve milk yield and quality, reduce veterinary costs, and ensure compliance with food safety standards. Moreover, they contribute to environmental sustainability through efficient resource use and responsible waste management. Implementing GDMPs ensures economic viability for farmers while promoting ethical treatment of animals and reducing the environmental footprint of dairy farming.

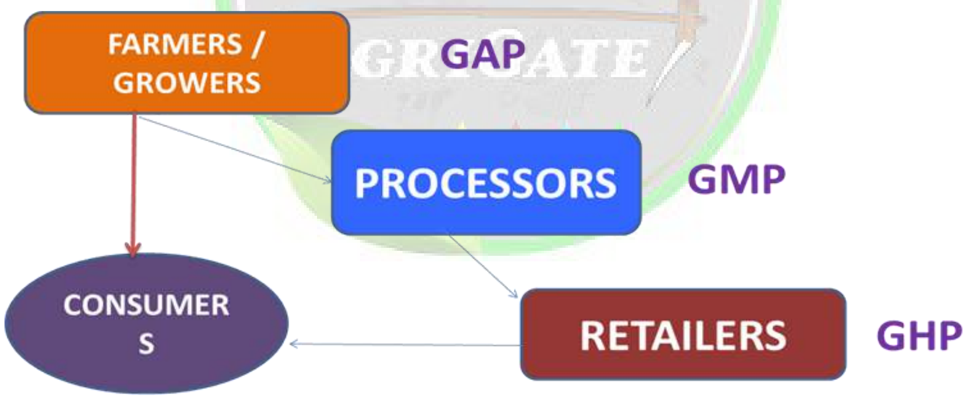
Key words: Dairy, Good management practices, Animal welfare

Introduction:

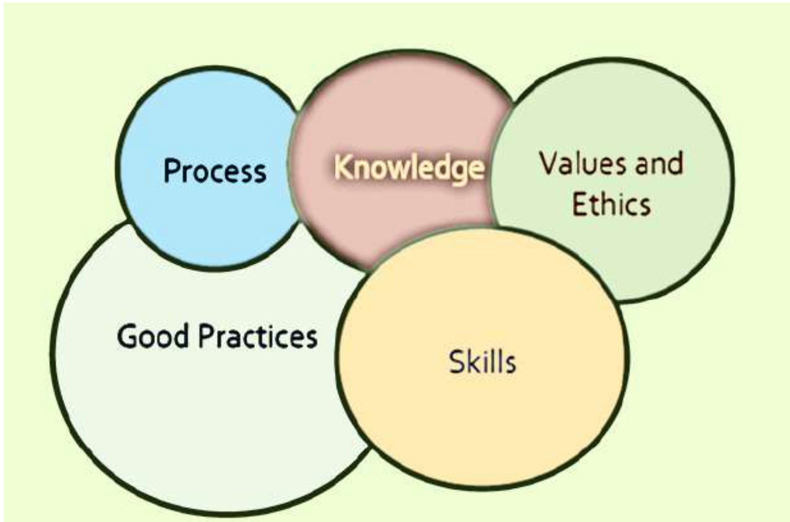
In India, 65 per cent of population lives in rural sector and mainly dependent on land & animals and animals as a whole play an important role in the agricultural economy. India has made huge progress in enhancing milk production in recent decades with an all-time high of 231 million tones. The rising population and increasing demand for milk and milk products, however, has led to calls for continued growth of milk production. Huge population of low producing bovine maintained by the large number of farmers in a traditional smallholder production system coupled with the constraints such as under nutrition, malnutrition, inadequate shelter and poor availability of breeding and healthcare facilities, with impaired productivity, health, welfare etc. are the major challenge in augmenting the milk productivity in a country. Dairy farmers' production systems worldwide need to be able to combine profitability with the responsibility of protecting human health, animal health, animal welfare and the environment. Dairy farmers, as the primary producers in the supply chain, should also be given the opportunity to add value to their product by adopting methods of production that satisfy the demands of processors and customers. The rising human population coupled with increasing demand for milk and milk products warrants faster growth in milk production.This calls for disseminating appropriate Good Dairy Management Practices (GDMPs) at field level.

Background for GDMP:

Good Agricultural Practice for dairy farmers is about implementing sound practices on dairy farms – collectively called Good Dairy Farming Practice. These practices must ensure that the milk and milk products produced are safe and suitable for their intended use, and also that the dairy farm enterprise is viable into the future, from the economic, social and environmental perspectives.



Most importantly, dairy farmers are in the business of producing food for human consumption so they must be confident in the safety and quality of the milk they produce. Good dairy farming practice underpins the production of milk that satisfies the highest expectations of the food industry and consumers. Good dairy farming practice also ensures that the milk is produced by healthy animals in a manner that is sustainable and responsible from the animal welfare, social, economic and environmental perspectives. These practices encourages dairy farmers to adopt 'proactive' preventative practices rather than waiting for problems to occur.



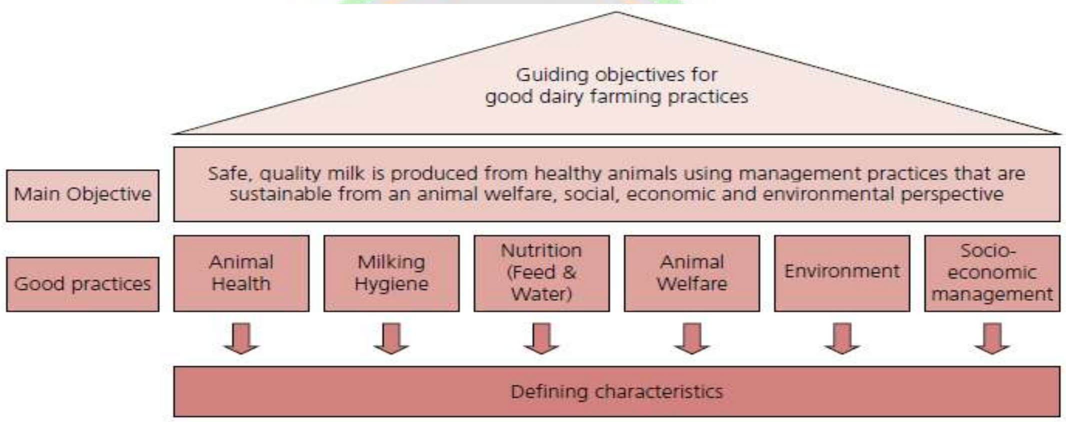
Good Dairy Management Practices (GDMP):

Good Dairy Management Practices (GDMPs) as a concept was introduced in 2004 (FAO and IDF, 2004) and it was later updated in 2011. GDMPs covers best part of every practice i.e. clean, scientific, organic, innovative, improved and natural dairy farming practices. GDMPs is an important practical tool used world-wide in supporting farmers to produce and market safe, quality milk and milk products to satisfy the expectations of the food industries and consumers (FAO, 2011). The aim is to ensure that the milk is produced at the farm level by healthy animals and in balance with the environment. GDMPs also ensure that the milk is produced in a sustainable manner as well as conforming to the animal welfare, socio-economic and environmental perspectives. GDMPs encourage dairy farmers to adopt 'proactive' preventive practices rather than waiting for problems to occur. The GDMPs tool box consist of six areas that need to be managed namely; Animal health, Hygienic milking, Nutrition, Animal welfare, Environment and Socio-economic condition. It is known that animal productivity and animal welfare are closely related and directly dependent on each other. Protecting animal welfare involves meeting the most basic animal needs, ensuring good feeding, good housing, good healthcare and good behavior and consequently good animal productivity. On the contrary, striving to attain very high levels of productivity puts physiological stress on the animal with resultant impaired health, reproduction and longevity. Welfare is a multidimensional concept. It comprises both physical and mental health and includes several aspects such as physical comfort, absence of hunger and disease, possibilities to perform motivated behaviour, etc.

Need for GDMPs:

- Number one in milk production
- Ensure that the milk and milk products produced are safe and suitable for their intended use, and also that the dairy farm enterprise is viable into the future, from the economic, social and environmental perspectives
- Most importantly, dairy farmers are in the business of producing food for human consumption so they must be confident in the safety and quality of the milk they produce
- Good dairy farming practice underpins the production of milk that satisfies the highest expectations of the food industry and consumers
- To exploit the opportunities for export

Components of GDMPs (FAO and IDF 2011):



1. Animal Health

Animals that produce milk need to be healthy and an effective health care programme should be in place. It describes good dairy farming practice to ensure animals that produce milk are healthy and there is an effective health care programme in place. However, not all of the practices are applicable in all circumstances and may be superseded by national, international or market demands.

The suggested good dairy farming practices for animal health are set out under the following headings:

• Establish the herd with resistance to disease

• Prevent entry of disease onto the farm

• Have an effective herd health management programme in place

• Use all chemicals and veterinary medicines as directed

2. Milking Hygiene:

Milking is the defining activity of dairy farming. Consumers demand high standards of milk quality, so milking management aims to minimize microbial, chemical and physical contamination. Milking management covers all aspects of the process of obtaining milk from animals quickly and effectively, while assuring the health of the animals and the quality of the milk. It describes the practices that ensure milk is harvested and stored under hygienic conditions and that the equipment used to harvest and store milk is well maintained.

The suggested good dairy farming practices for milking hygiene are set out under the following headings:

• Ensure milking routines do not injure the animals or introduce contaminants into milk.

• Ensure milking is carried out under hygienic conditions.

• Ensure milk is handled properly after milking.

3. Nutrition:

The quantity and quality of the feed and water provided largely determines the dairy animal's health and productivity, and the quality and safety of its milk. It describes good dairy farming practice for managing animal nutrition, both feeding and watering. The suggested practices are set out under the following headings:

• Secure feed and water supplies from sustainable sources.

• Ensure animal feed and water are of suitable quantity and quality.

• Control storage conditions of feed.

• Ensure the traceability of feedstuffs brought on to the farm.

5. Environment

Increasingly, consumers are concerned that the production of food is sustainable and is undertaken in harmony with the environment. To meet these concerns it is important that dairy farmers produce milk in a way that meets the wider community's expectations, by using natural resources efficiently and minimizing any adverse impact on the environment. Every dairy farmer can play a role in protecting their industry and the future of their enterprise by adopting management practices that enhance the environmental sustainability of their farming system.

The suggested good dairy farming practices for the environment are set out under the following headings:

• Implement an environmentally sustainable farming system.

• Have an appropriate waste management system.

• Ensure dairy farming practices do not have an adverse impact on the local environment.

6. Socio-Economic Management

Being ‘socially responsible’ and ‘economically sustainable’ are integral to good dairy farming practice as they address two key risks to the farm enterprise. Managing and looking after the farm’s human resources is critical to the sustainability of the enterprise. In many parts of the world this will primarily apply to the farmer and others living on the dairy farm. However, dairy farmers must also consider the role their enterprise has in the wider community; as an employer, consumer of natural resources and its potential impact on neighbours. Similarly, dairy farms are businesses producing a product, in this case milk, meat and livestock. Like all businesses, dairy farm businesses must be financially viable to have a long term future.

The suggested good dairy farming practices for the socio-economic management of dairy farms are:

• Implement effective and responsible management of human resources.

• Ensure farm tasks are carried out safely and competently.

• Manage the enterprise to ensure its financial viability.

Factors influencing GDMP adoption:

- The price received by the produces, health consciousness of consumers, economic loss to farmer due to disease burden, extent of extension support and future scope of dairying will also be the defining factors of GDFP adoption
- The major challenges in promoting GDFP are lack of awareness among farmers and other stakeholders, bio-physical constraints, rampant adulteration in milk and milk products, synthetic milk, poor infrastructure, false propaganda, harmonizing global standards, needed government programmes and affordable prices for the milk and milk products

Conclusion

Good Dairy Management Practices (GDMPs) are critical for optimizing dairy cattle production. By focusing on animal health, milk quality, environmental sustainability, and cost efficiency, GDMPs ensure that dairy farms are not only more productive but also more sustainable and ethical. The challenges such as poor awareness about hygienic milk production practices, lack of budgetary support, ineffective implementation of laws regulating the safe supply of milk and milk products and prevalence of adulteration and synthetic milk need to be tackled through appropriate strategies. This requires strong policy support, sensitization of all stakeholders, complimentary extension delivery system, credit support to practice GDMP and convergence of efforts of various agencies.

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GRAFTING TECHNIQUES IN VEGETABLE CROPS

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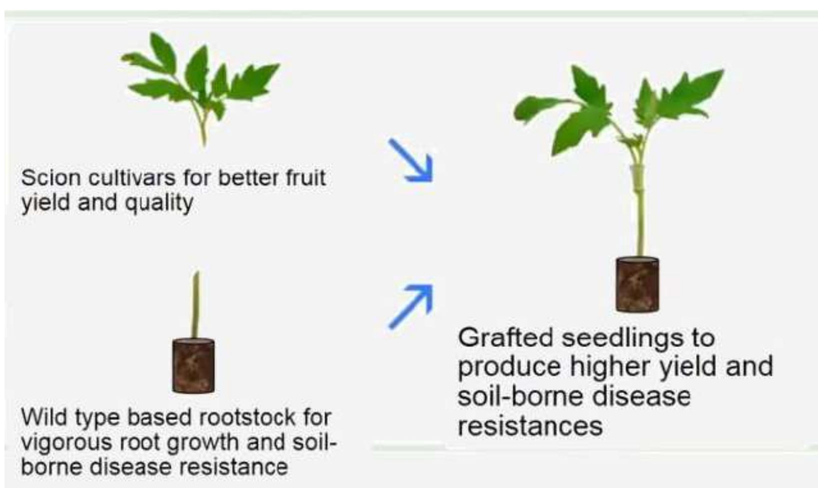
Introduction

It is the process of operation of inserting a part of plant into another plant. It is formed the union and the combination will continue to grow as a single plant is called grafting. The grafted plant contains two portions a) the upper portion is called as scion – chosen based on fruit quality and improved yield b) the lower potion or root is called as rootstock - chosen for its genetic ability to resist/tolerant to biotic and abiotic stress (Fig 1). Some vegetables that can be grafted together include: Tomato, Brinja, Cucumbers, Melons and Squashes.

Fig 1. Vegetable Grafting.



History of vegetable grafting

- In Japan and Korea in the late 1920s, this method was initially applied by grafting watermelon (Citrullus lanatus) onto pumpkin (Cucurbita moschata) rootstock.
- In vegetable crops grafting techniques are widely performed in solanaceous crops (tomato and brinjal) and cucurbitaceous (cucumber, watermelon and muskmelon).

Why grafting is needed in vegetables?

- ✓ Vegetable production is highly affected by biotic and abiotic stress.
- ✓ Grafting of susceptible scions on the resistant rootstock is become an effective alternative against soil borne pathogens.
- ✓ Eco-friendly in nature

Advantages of Grafting in Vegetables

- Better resistance to pathogens - The risk of soil-borne diseases such as fusarium wilt, verticillium wilt, and root nematode can be decreased by grafted plants' potential for disease-resistant roots.
- Drought and other environmental stress can be overcome by grafted plants.
- Reduce the use of pesticides,
- More vigorous growth and
- Higher yield

Methods of Grafting in Vegetables

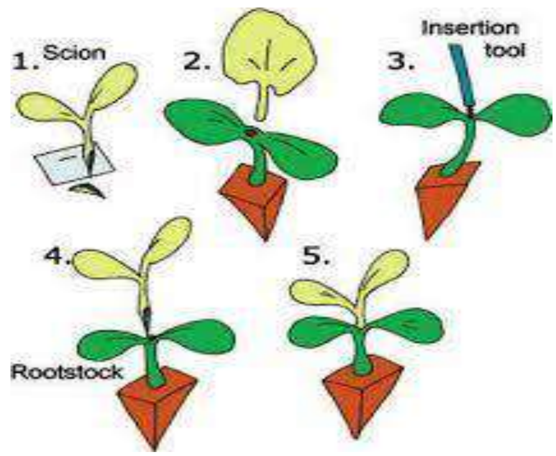
Hole insertion

This is the most widely used method for cucurbits because its having hollow hypocotyls in the scion and rootstock are recommended. The grafted watermelon transplant production method of choice is this one since watermelon seedlings are smaller than bottle gourd or squash rootstock. The ideal temperature range for this procedure is 21–36˚c till transplantation. In comparison to the tongue grafting technique, this method is highly popular in China since it produces a robust union and vascular connection. It's also known as top insertion method (Fig 2).

- **Cleft grafting**

  This is a commonly used grafting technique for solanaceous crops. Here, scion plants are trimmed to have one to three true leaves. The lower stem is then cut at an angle to create a tapering wedge, and once the scion is inserted into the split, a clip is inserted to make contact with the rootstock.

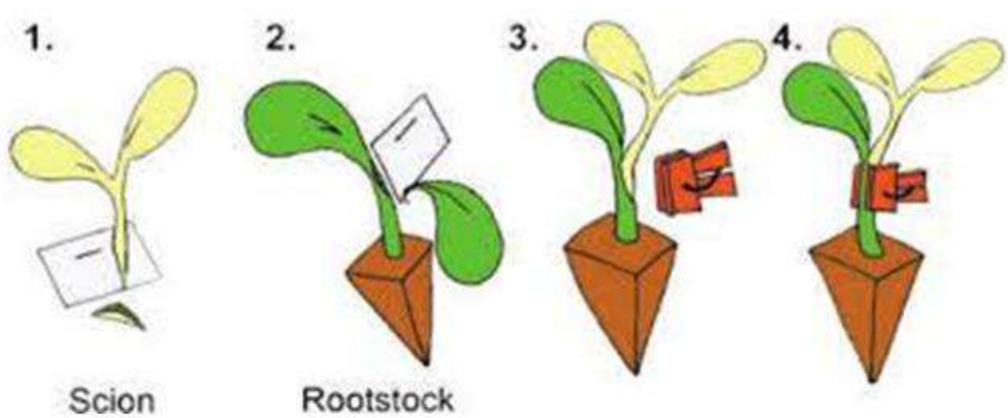
Fig 2. Hole insertion or top insertion grafting.



- **Splice grafting**

One true leaf should be present in rootstock seedlings, while two true leaves should be present in scion seedlings. Make a 60° angle cut in the rootstock such that one cotyledon remains and one is removed. Make sure you cut with careful to preserve the surviving cotyledon securely linked to the rootstock stem. The apical meristem of the remaining cotyledon should likewise be removed by the angled cut. It is also known as tube or one cotyledon splice grafting (Fig 3).

Fig 3. Splice grafting or one cotyledon splice grafting.



- **Pin grafting**

  Pin grafting is similar to splice grafting. Precisely made pins are utilized for holding the grafted portion in the replacement of grafting clips.

- **Tongue grafting**

  For this grafting, equal-sized rootstock and scion material were utilized. Scion seeds are therefore seeded 5-7 days earlier than rootstock seeds in order to achieve uniform growth.

Due to its high seedling survival rate and labour-intensive nature, this approach is most commonly employed by small nurseries and farmers. Hollow hypocotyl rootstocks are ineligible for this approach. This method is also known as approach grafting.

Table 1. Grafting methods, rootstock and its features of vegetables

Scion plant	Rootstock	Features	Method of grafting
Tomato	*Solanum pimpinellifolium*	Nematode resistant	Cleft grafting
	Solanum nigrum	Fruit size and quality	Tongue and cleft grafting
Brinjal	*Solanum sissymbrifolium*	Resistant to little leaf of brinjal, immune to root knot nematode	Cleft grafting
	Solanum torvum	Disease resistant and nematode tolerant	Tongue and cleft grafting
	Solanum khasianum	Resistant to shoot and fruit borer	Tongue and cleft grafting
Cucumber	*Cucurbita moschata*	Fusarium wilt tolerance	Hole insertion and Tongue grafting
	Cucurbita maxima	Fusarium wilt tolerance, low temperature tolerance	Tongue grafting
	Cucurbita ficifolia	Low temperature tolerance	Cleft grafting
Watermelon	*Cucurbita moschata*	Fusarium wilt tolerance, low temperature tolerance	Hole insertion and Cleft grafting
	Benincasa hispida	Disease resistance	Hole insertion and

			Cleft grafting
	Lagenaria siceraria	Fusarium wilt tolerance, low temperature tolerance	Splice grafting
Bitter gourd	*Cucurbita moschata*	Fusarium wilt tolerance, low temperature tolerance	Hole insertion and Tongue grafting
Bottle gourd	*Cucurbita moschata*	Fusarium wilt tolerance, low temperature tolerance	Hole insertion and Tongue grafting

Achievements

Pomato (Potato + Tomato)

Grafting of tomato or cherry tomato cultivar on seedlings of potato seedlings is called pomato. This technique was developed by Indian Institute of Vegetable Research (IIVR), Varanasi, Uttar Pradesh. The Grafting was done by cleft or side method. About a single pomato plant were produced 1.5- 2.0 kg of tomatoes and 0.5-0.8 kg of potatoes (Fig 4).

Fig 4. Pomato (Potato + Tomato)

Fig 5. Brimato (Brinjal + Tomato)

Brimato (Brinjal + Tomato)

The Dual Grafting of Brinjal and Tomato (Brimato) was demonstrated in the field during 2020-21 by Indian Institute of Vegetable Research (IIVR), Varanasi, Uttar Pradesh. The Brinjal

Hybrid - Kashi Sandesh and improved cultivar of Tomato - Kashi Aman were successfully grafted into brinjal rootstock - IC 111056. The Grafting was done by side/ splice method. It gives 2.383 kg of tomato/ plant, and 2.684 kg of brinjal/ plant (Fig 5)

Conclusion

The production of vegetables requires dealing with numerous biotic and abiotic stresses. It takes a lot of time and effort to introduce genes for stress resistance or tolerance in crop plants. Grafting is the simple and effective way to overcome these hurdles in the vegetable production.

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TRAINING ENHANCES THE SKILLS OF FARMERS IN VIRUDHUNAGAR DISTRICT

Article ID: AG-VO4-I10-76

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Introduction

This study was conducted in Virudhunagar district. Three blocks were selected viz., Aruppukottai, Kariyapatti and Thiruchuli. The farmers were considered as the respondents. For this study the size of the sample was 100. The farmers were selected from Aruppukottai, Kariyapatti and Thiruchuli. Simplee Random sampling was followed and the design of this study is "Expot Facto". Hence, this study analysis about the preferences of training programmes of Krishi Vigyan Kendra, Virudhunagar by survey method. Data collection tool was an Interview schedule. This was used to conduct survey and collect data. The specific objectives of the study were, to study the profile characteristics of the respondents, to explore the income generation activities of farmers of Virudhunagar district. to study the needs of trainings of farmers of Virudhunagar district. to study the constraints to attend the training programmes.

The data collected were analysed through percentage analysis. After analyzing the data the following tables were prepared objective wise. Hence, the following tables lead to the salient findings of this research project as per the proposed objectives. The data collected from the respondents were coded, tabulated, analyzed and presented in the form of tables in order to make the findings meaningful. The findings emerged from the analysis of data were suitably interpreted and conclusions were drawn. The ability of an individual to perform certain tasks is generally associated with their chronological age and experience in performing the particular task. The objectives of the study were, to study the profile characteristics of the respondents, To explore the income generation activities of farmers of Virudhunagar district, to study the preferences of trainings of farmers of Virudhunagar district, to study the constraints of the farmers in attending training programmes.

Table: 1.Distribution of respondents according to their training need preferences

n=100

Sl.No.	Training need	Number	Percentage (%)
1.	Seed production in pulses	100	100
2.	Marketing and post harvest practices of minor millets	92	92
3.	Goat rearing and feed preparation	68	68
4.	Mushroom spawn production	100	100
5.	Fodder cultivation techniques	72	72
6.	Disease Management in cotton	84	84
7.	Pest management in cotton	81	81
8.	Fruit trees cultivation in Dryland	84	84
9.	Cultivation Techniques in Onion	62	62
10.	Preparation of Panchackaviya	54	54
11.	Organic farming practices	90	90
12.	Bee keeping technologies	63	63
13.	Kuthiraivali Cultivation and value addition	84	84
14.	Processing techniques of Minor millets	84	84
15.	Water harvesting techniques in rainfed areas	75	75
16.	Integrated farming system	63	63
17.	Fish pond and fish rearing	12	12
18.	Rearing country chicken and poultry techniques	69	69
19.	Vegetable production and value addition	60	60
20.	Value addition in fruits	39	39

Table:2.Distribution of respondents according to their preference on type of training venue, season, duration, timings Trainer, Training method n=100

SL.No.	Training components	Number	Percentage (%)
1.	**Training Type**		
a)	Peripatetic training	76	76
b)	Institutional training	24	24
2.	**Venue of Training**		
a)	Village	35	35
b)	Panchayat Union Office	28	28
c)	Krish Vigyan Kendra	37	37
3.	**Season of training**		
a)	Kharif	36	36
b)	Rabi	-	-
4.	**Duration of training**		
a)	One day	65	65
b)	Two day	32	32
c)	One week	3	3
5.	**Timings of training**		
a)	Fore Noon	40	40
b)	Afternoon	60	60
6.	**Trainer**		
a)	Progressive farmer	15	15
b)	Scientists	60	60
c)	Extension officers	22	22
d)	NGO trainer	3	3
7.	**Training method**		
a)	Lecture		65
b)	Discussion	74	74
c)	Demonstration	86	86

d)	Field visit	72	72
e)	Exhibitions	68	68
f)	Lecture and Video	56	56
8.	**Participation**		
a)	One training	65	65
b)	Two training	28	28
c)	No training	7	7

Table 3: Distribution of respondents according to their constraints in attending training programme n=100

SL.No.	Constraints	Number	Percentage (%)
1.	Lack of technical guidance to attend training	14	14
2.	Not able to attend training programme	42	42
3.	Lack of information on training	35	35
4.	Details given by extension officer, not understandable	28	28
5.	Not convinced with the recommended practices	35	35
6.	Undesirable climate to travel	8	8
7.	High transport cost	7	7

Preference of Training Programme

Mendelhall and Reinmuth (1974) defined the dependent variable as the variable of interest which were said to be functionally related to one or more independent or predictor variables. The dependent variable of this study is preference of training programme of Krishi Vigyan Kendra, Virudhunagar.

Training need

Training need in this study has been operationalised as the required level of training by respondents. It was decided to conduct the study with training need with the dimensions of subject matter area, type, venue, duration, timings, season, training methods and trainers.

Subject Matter

Subject matter of KVK's training programme were identified in consultation with extension workers, scientists of KVK and by reviewing previous research studies.

Type of training

There are two types of training. The first type is peripatetic training where the training is given by the subject matter specialists to the trainees at the villages, either in farmers' field itself under natural setting or in any common place in the village. Second are is institutional training which is given by the subject matter specialists in any situation.

Trainings Undergone

Agricultural technologies are generated to cater to the needs of the farmers. As these techniques require science and skill it requires understanding and acquiring skills. Thee coming forward to participate in various training programmes would support the farmers to adopt new techniques in farming.

Venue of Training

Venue of training referred to the place where the farmers preferred to undergo training.

Season of training

The season is referred as the seasons (Summer, winter, kharif, Rabi) during which farmers preferred to undergo training.

Duration of training

Duration referred to the number of days of trainings farmers willing to undergo.

Timings of Training

This referred to the sessions of the day such as Forenoon, Afternoon and full day during which the farmers preferred to undergo training.

Trainer

This referred to the person who had to conduct training for different subjects. Trainers namely extension officers of the State Department of Agriculture and the Scientists of Tamil Nadu Agricultural University, Progressive farmers and staff from NGOs' were identified as trainers.

Method of Training

Nine training methods viz, lecture, discussion, demonstration, field visits, exhibition, study tour or exposure visits, lecture and video sessions, lecture and you tube demonstrations, and power point presentations were found as common training methods.

Constraints faced by the trainers

Constraint analysis is becoming are of the important components of extension research. Without analyzing the constraints it is impossible to diffuse the technologies among the farming community. The various constraints according to Janakirani (1999) the constraints were enumerated. The possible constraints were enumerated from related studies in consultation with farmers and scientists.

The results were expressed in percentage. The respondents were distributed as young farmers (15%) and middle aged farmers (46%) and old aged farmers (39%).

- With regard to the educational status 48 per cent of the respondents were educated upto secondary level followed by 29 per cent middle school level and 10 per cent upto higher secondary level. Collegiate level literates were only 3 percent among the respondents.
- Among the respondents 61 per cent were coming under the category middle income group followed by 24 percent high income group.
- Majority of 59 per cent of the respondents were having Agriculture as the main occupation followed by 24 per cent with Agriculture and allied occupation.
- The respondents were distributed based on their extension agency and 55 per cent had medium level of extension agency contact followed by 25 per cent had low level of extension agency contact. The high level of extension agency contact (20%) was observed.
- A vast majority of 66 percent of the respondents had a medium level of social media exposure followed by 22 per cent had a high level of social media exposure.
- All the respondents (100%) had television in their have followed by 96 percent had mobile phones, 88 per cent had farm equipments, 85 per cent had refrigerator, 72 per cent had lab top and only 36 percent possess washing machine. The tractor was owned by only 6 percent of the farmers.

Preferred Training Technologies

- All the respondents (100%) preferred seed production technologies, Mushroom spare production.
- A vast majority of 92 percent of the farmers were interested to study marketing and post harvest practices of minor millets and 90 percent were interested in organic farming practices.

- Majority of 84 per cent of the respondents preferred disease management in cotton, processing techniques of minor millets, Kuthiraivalli cultivation and value addition, fruit trees cultivation in Dryland and 81 per cent had shown interest on pest management in cotton. Majority of 68 per cent were interested in goat rearing and feed preparation, 63 per cent on beekeeping technologies and integrated farming system and 69 percent were interested in rearing country chicken and poultry techniques.
- Among the training components preferred 76 per cent of the respondents preferred peripatetic training, 35% of the respondents preferred village as venue of training and 337 percent preferred training venue as Krishi Vigyan Kendra.
- A vast majority of 64 percent of the respondents preferred training should be conducted during summer and 65 per cent preferred only one day training. a vast majority soft 60 per cent of the respondents preferred the trainer as scientists and 22 percent preferred extension officers.
- Among the different training methods studies a vast majority (86%) preferred demonstration followed by discussion (74%), Field visit (72%), exhibitions (68%), Lecture method (65%), lecture + video (54%), Lecture + power point slides (48%).
- Among the constraints faced by the respondents 35 per cent of the respondents felt that lack of information on training and not convinced with the recommended practices.
- The constraint, not able to attend the training programme was felt by 42 per cent of the training programme and lack of technical guidance (14%), undesirable climate to travel (8%) and high transport cost (7%).

Conclusion

From this study it is concluded as most of the respondents (65%) preferred one day training and also most of them (60%) preferred afternoon and evening hours for training. Regarding the preference toward trainers most of the respondents preferred (60%) scientists. Respondents preferred demonstration method of training for transfer of skill (86%). Regarding the constraints experienced by the respondents only a few had expressed undesirable climate as the constraint.

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ENHANCING YIELD AND STRUCTURE IN CASTOR PLANTS THROUGH NIPPING TECHNIQUES

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Abstract

Nipping, commonly referred to as pinching or topping, is an essential agronomic practice in the cultivation of castor plants, aimed at improving both plant structure and overall productivity. Given that castor plants tend to grow tall and robust, nipping involves the removal of the apical bud, which redirects growth towards the lateral branches. This technique encourages the formation of side branches, thereby increasing the number of flowering points and enhancing seed production. There are two main methods of nipping: manual and chemical. Manual nipping entails the physical removal of the upper part of the plant, while chemical nipping employs plant growth regulators such as mepiquat chloride, paraquat or 2,4-D to manage vertical growth. This practice optimizes the plant's architecture, allowing for better sunlight exposure, improved air circulation and enhanced photosynthesis. Additionally, nipping contributes to a more uniform plant height, which is advantageous for mechanized harvesting, minimizes lodging, and improves the distribution of resources, ultimately leading to higher seed and oil yields.

Furthermore, nipping has a synergistic effect with other agronomic practices, including defoliation, irrigation, and nutrient management, thereby increasing overall efficiency. The selection of nipping technique and its timing are critical, as different castor hybrids may respond differently to manual and chemical approaches. When effectively implemented, nipping can lead to substantial yield increases, enhanced economic returns, and greater sustainability in castor farming, particularly in high-density and irrigated environments.

Key words: Castor, mepiquat chloride, nipping , yield, manual nipping.

Introduction:

Nipping, also known as pinching or topping, is a key agronomic practice in castor cultivation that improves plant structure and overall productivity. Castor plants tend to grow tall and vigorous, dominated by an apical bud that controls the plant's growth. Nipping involves removing this apical bud or the top part of the plant to redirect growth toward lateral branches. This adjustment alters the plant's growth pattern, encouraging the development of side branches, which increases flowering points and boosts seed yields. Nipping is especially important for crops like castor, grown for both seeds and stalks. By creating a more compact and uniform plant structure, it not only enhances yields but also facilitates better management practices, such as mechanized harvesting. Removing the apical bud helps the plant use its resources more efficiently, resulting in higher seed production per unit area while limiting excessive vegetative growth.

In castor farming, nipping promotes lateral branching, increasing the number of racemes and seed yield while forming a compact plant structure suitable for both manual and mechanized harvesting (Stefanoni *et al.*, 2020). It shifts the plant's energy from vertical growth to reproductive development, optimizing the use of resources. Moreover, by improving light penetration and air circulation in the canopy, nipping enhances photosynthesis and reduces the risk of diseases, making it a crucial practice for maximizing yields in sustainable agricultural systems.The main goal of nipping is to modify plant growth, encourage side branching, and ultimately increase both seed and stalk biomass.

1. **Types of nipping practices:**

- **Manual Nipping**:

Manual Nipping is a traditional agronomic practice used in the cultivation of castor plants, where the top part of the plant, specifically the apical bud, is physically removed by hand

(Fig.1). This technique, performed around 45-50 days after sowing (DAS), plays a critical role in redirecting plant growth from vertical to lateral, promoting the development of side branches. Manual nipping is commonly employed by small-scale and resource-limited farmers due to its simplicity and effectiveness in increasing seed yield (Baloch *et al.*, 2010).

Process of manual nipping:

Timing:

Manual nipping is generally performed when the plants are in their early vegetative stage, typically around 45-50 DAS, or when the plants have developed 5-6 true leaves. This is the optimal period to nip the apical bud and encourage branching without negatively impacting overall plant growth.

Method:

The process involves manually pinching or cutting the apical bud (the dominant growth point) located at the top of the plant using hands or simple tools. By removing the apical bud, the apical dominance is broken, causing the plant to shift its growth energy towards lateral buds, which promotes branching and increased flowering sites.

- **Chemical nipping**:

Mepiquat chloride:

Chemical nipping, particularly using **mepiquat chloride**, is a method used in crops to manage plant growth by inhibiting excessive stem elongation(Fig.1). Mepiquat chloride (MC) is a plant growth regulator (PGR) commonly used in agriculture, especially in cotton, but it is also gaining importance in crops like castor for controlling growth patterns (Sanbagavalli *et al.*, 2020).

Figure.1. Comparison of manual nipping and mepiquat chloride spray

Paraquat:

Paraquat is a powerful and widely used **desiccant herbicide**, often employed in agriculture to induce chemical nipping by desiccating (drying out) the top part of plants. It is a fast-acting, non-selective herbicide that causes rapid plant tissue death upon contact, making it effective for a range of purposes including weed control, crop desiccation and growth management.

2,4-D:

2,4-D is a synthetic auxin (a plant hormone) that mimics the natural growth hormone auxin, promoting abnormal growth patterns in susceptible plants. Upon application, it is absorbed by the plant and trans-located throughout the tissues. This leads to uncontrolled and rapid growth in the treated area, causing cells to elongate excessively, which can ultimately result in tissue death (necrosis) in targeted plants.

Comparison:

While manual nipping is more labor-intensive, chemical nipping is faster and can be easily applied over large areas but needs careful calibration to avoid plant damage.

2. Physiological impact of nipping on castor plants:

- **Promotion of lateral branching**: Nipping the apical bud removes apical dominance, redirecting plant resources towards the development of lateral branches.
- **Enhanced photosynthesis**: Better branching leads to an improved canopy structure, allowing more sunlight penetration to lower leaves, enhancing overall photosynthetic activity.
- **Control of excessive vegetative growth**: Chemical nipping agents like mepiquat chloride reduce vertical growth, leading to better plant energy allocation toward reproductive structures.
- **Root system development**: Some studies suggest that nipping also influences root development by balancing above-ground and below-ground growth.

3. Optimal timing and stage for nipping:

- **Growth stage**: Nipping is typically performed between 40-50 DAS when plants have about 5-6 true leaves. The exact timing may vary depending on the cultivar and local agronomic conditions.

- **Importance of timing**: Delayed nipping can negatively impact the overall plant architecture, while early nipping can stunt growth. Proper timing ensures better branching and improved yield potential.
- **Interaction with growth regulators**: In chemical nipping, timing is crucial for the effectiveness of agents like mepiquat chloride, which should be applied when vegetative growth starts to dominate.

4. Agronomic benefits of nipping:

- **Increased yield**: By encouraging more lateral branches, nipping increases the number of flowering points, resulting in a higher number of seed capsules.
- **Uniform growth**: Nipping leads to a more uniform plant height, which is especially advantageous in mechanized harvesting systems.
- **Reduced lodging**: By controlling vertical growth, nipping helps in reducing lodging (falling over of plants), which is a common problem in castor cultivation under high-density planting.
- **Improved harvest efficiency**: Uniform plant height and better branching make it easier for mechanized harvesters to collect seeds without missing capsules or damaging plants.

5. Interaction with other agronomic practices:

- **Defoliation**: Nipping is often combined with defoliation (removal of leaves) at certain growth stages to regulate plant growth and improve seed fill.
- **Irrigation management**: Proper irrigation during the early stages of plant growth, combined with nipping, can significantly enhance growth and yield.
- **Fertilizer application**: Balanced nutrient management post-nipping helps sustain the increased demands for nutrients by lateral branches and reproductive structures.
- **Pest and disease control**: Nipping creates an open canopy that reduces humidity within the plant stand, making it less conducive for pests and diseases.

6. Effect of nipping on economic efficiency:

- **Higher seed and oil yields**: Nipping, especially when combined with chemical applications, can lead to significant increases in seed yield, translating into better returns for farmers.

- **Cost-effectiveness**: Chemical nipping is less labor-intensive but incurs input costs for chemicals. Manual nipping is labor-intensive but cost-effective in small farms with available labor.
- **Mechanization**: Uniformity in plant height as a result of nipping facilitates mechanized harvesting, reducing labor costs and improving harvesting efficiency.
- **Return on investment (ROI)**: Studies show that the ROI from nipping can be substantial, especially in high-density planting systems, where increased branching leads to higher productivity per hectare.

7. Nipping and castor hybrids:

- Different castor hybrids (e.g., **YRCH-1, YRCH-2, ICH-66, DCH-519**) may respond differently to nipping practices. Research at Tamil Nadu Agricultural University, for example, focuses on determining the best hybrid-nipping combination for maximizing yield in irrigated systems.
- **Growth response**: Some hybrids may exhibit stronger branching tendencies, while others may benefit more from chemical nipping practices.
- **Yield variability**: The influence of nipping on yield also varies across hybrids, making it important to tailor the practice to specific hybrid characteristics.

8. Challenges and risks in nipping:

- **Over-application of chemicals**: Misapplication of growth regulators like paraquat or 2,4-D can cause excessive tissue damage and negatively affect yield.
- **Labor availability**: Manual nipping requires skilled labor, which may not always be available, especially during peak agricultural seasons.

Conclusion

Overall, nipping enhances economic efficiency by increasing seed and oil yields, supporting mechanization, and improving return on investment (ROI), especially in high-density planting systems. Despite its challenges, such as labor availability, nipping remains a valuable tool for sustainable and productive castor cultivation.

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SILICON IN THE MANAGEMENT OF PLANT DISEASES

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Introduction

Silicon (Si), the second most abundant element in the earth's crust after oxygen, is absorbed by plant roots as monosilicic acid (H_4SiO_4). Though not essential, it is considered beneficial, enhancing drought tolerance, metal toxicity resistance, and reducing disease and pest severity. When combined with proper soil management and favorable conditions, Si can help improve crop yields.

The beneficial effects of silicon (Si) in reducing disease intensity were first observed in monocots, such as grasses, in the 1960s due to its easy uptake and accumulation. In rice, Si was linked to lower incidence and severity of diseases like rice blast, brown spot, and sheath blight (Jones & Handreck, 1967).

Silicon (Si) has also been linked to controlling rust (*Puccinia melanocephala*) in sugarcane, *Blumeria graminis* f. sp. *tritici* in wheat, and *Erysiphe graminis* in barley. Promising results in disease intensity reduction have been observed in various pathosystems, including Cercospora leaf spot and rust in coffee (Pozza *et al*., 2004).

The effects of silicon (Si) on plant disease control and its mechanisms in various pathosystems remain not fully understood. One hypothesis suggests that Si forms a physical barrier through its accumulation in plant cell walls. As Si moves upward via the apoplast from roots to leaves, it polymerizes in the extracellular spaces, accumulating on the walls of leaf epidermal cells and xylem vessels (Samuels *et al*., 1991).

Silicon in disease control in monocotyledons and dicotyledons

Studies on silicon (Si)-induced disease control began with monocotyledons, especially rice and grasses known as Si accumulators. Si application has shown promising results in managing diseases in rice, including rice blast (*Pyricularia grisea*) and brown spot (*Bipolaris oryzae*), where its effects were comparable to fungicides like Benomyl and Propiconazole. In rice brown spot, Si application reduced disease severity by 55% (Zanão Junior *et al*., 2009), with effectiveness depending on soil application. Si also reduced sheath blight (*Rhizoctonia solani*) severity and showed promise in other monocot pathosystems, including anthracnose in sorghum, rust in sugarcane, and powdery mildew in wheat and barley.

Si has been effective in controlling powdery mildew (*Sphaerotheca fuliginea*) in cucurbits, reducing spore germination and colony formation on cucumber leaves. Si also influences bean anthracnose (*Colletotrichum lindemuthianum*), extending the incubation period and reducing disease severity. In coffee, Si has shown promising results in managing Cercospora leaf spot, rust, and phoma/ascochyta leaf spot. These findings highlight Si's potential in controlling diseases across various dicot crops (Belanger *et al*., 2003).

Modes of silicon action in plant disease control

The modes of silicon (Si) action in plant disease control are not fully understood, but its effectiveness is attributed to both physical and chemical barriers. Physically, Si deposits in plant tissues, forming barriers such as thicker cell walls (Kim *et al*., 2002). Chemically, Si enhances plant defense by activating enzymes like peroxidase and polyphenoloxidase (Fauteux *et al*., 2005). Studies suggest that these physical and chemical defenses work together to reduce disease. Si may also enhance nutrient absorption and strengthen resistance structures like the wax layer and cell wall.

The hypothesis of silicon (Si) forming a physical barrier in plants is based on its accumulation during upward movement via the apoplast from roots to leaves. Si, absorbed as monosilicic acid, travels through the transpiration stream and polymerizes in the extracellular spaces, forming a cuticle-silica double layer beneath the leaf cuticle. This layer strengthens the plant's defense, delaying pathogen penetration, as seen in rice against *Pyricularia grisea* (Kim *et al*., 2002) and in vine seedlings against *Uncinula necator* (Bowen *et al*., 1992).

In cucurbits, a similar Si barrier reduced the penetration of *Sphaerotheca fuliginea* (Menzies *et al*., 1992). Coffee seedlings with a well-developed wax layer on the abaxial leaf surface showed reduced Cercospora leaf spot severity, attributed to this physical barrier (Pozza *et al.*, 2004). This thickened wax layer hampers pathogen entry, demonstrating the protective role of Si accumulation in various plant species.

Conclusion

In conclusion, while all essential nutrients impact the occurrence and severity of plant diseases, silicon (Si), though not classified as an essential nutrient, plays a crucial role in reducing disease intensity across various crops. Although the exact mechanisms remain unclear, it is hypothesized that Si may contribute to plant resistance by acting as a physical barrier through its deposition in plant cell walls, thereby preventing pathogen entry. Moreover, Si-treated plants show enhanced activity of defense-related compounds such as phenolics, polyphenol oxidases, and peroxidases, indicating its role in activating plant defense responses. This review highlights the importance of Si in disease control and explores the potential mechanisms that underpin its contribution to plant disease resistance.

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COMPREHENSIVE INSIGHTS INTO LAND USE AND LAND COVER

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Abstract

Land Use and Land Cover (LULC) studies are essential for understanding the dynamic relationship between human activities and the natural environment. This article provides a comprehensive overview of the historical development, classification, and applications of LULC, emphasizing its importance in environmental monitoring, urban planning, agriculture, and disaster management. The integration of modern technologies such as remote sensing, Geographic Information Systems (GIS), and drones has significantly advanced the accuracy of LULC mapping. Despite these advancements, challenges such as data availability, climate variability, and policy implementation remain. Future developments in LULC studies will focus on sustainable land management practices and global collaborations, crucial for addressing environmental challenges such as deforestation and climate change.

Keywords: Land Use and Land Cover (LULC), Remote sensing, Geographic Information Systems (GIS), Sustainable land management

Introduction

Land Use and Land Cover (LULC) refer to two distinct yet interconnected aspects of the Earth's surface. **Land Use** involves the management and modification of the natural environment or wilderness into built environments such as settlements and semi-natural habitats like arable fields, pastures and managed woods. **Land Cover**, on the other hand, refers to the physical material that covers the Earth's surface, including vegetation, urban infrastructure, water and other physical features. LULC studies are essential in understanding the dynamics of environmental change, human activities and their impacts on ecosystems. With the growing influence of human activities on global landscapes LULC studies provide crucial insights for sustainable management and conservation of natural resources.

Historical Background of LULC

The study of LULC has evolved significantly over the centuries. Early land use was largely driven by agricultural needs with societies transitioning from nomadic lifestyles to settled farming. As civilizations grew, so did the complexity of land use with the development of cities, trade routes and infrastructure.During the Industrial Revolution land use practices underwent significant changes with urbanization, industrialization and the expansion of transportation networks. These changes led to significant alterations in land cover including deforestation, wetland drainage and the creation of artificial landscapes. In the 20th century, technological advancements such as remote sensing and geographic information systems (GIS) revolutionized LULC studies. These technologies enabled more accurate mapping, monitoring and analysis of land use and land cover changes providing essential data for environmental management and policy making.

Definition of Land Use and Land Cover

Land Use is the manner in which humans utilize the land, encompassing a variety of activities such as agriculture, residential development, industry, recreation and conservation. It reflects the human influence on the landscape and includes the infrastructure and modifications made to the natural environment to support these activities (Nedd *et al*., 2021).

Land Cover represents the physical state of the land surface including forests, water bodies, urban areas and barren lands. It describes the natural and human-made features that are visible on the Earth’s surface and is used to study environmental and ecological processes (Baronian *et al*., 2024).

1. Importance of LULC Studies

Land Use and Land Cover (LULC) studies are crucial for understanding and managing natural resources, urban planning and environmental conservation. Here's why LULC studies are important:

1.1. Environmental Monitoring

Monitoring changes in land cover is crucial for tracking deforestation, urban expansion and desertification. LULC data helps in understanding the ecological impacts of these changes and in developing strategies for biodiversity conservation and climate change mitigation.

1.2. Urban Planning and Development

LULC studies inform urban planning by providing data on land availability, infrastructure needs and environmental impacts. This information is crucial for sustainable city development, zoning regulations and managing urban sprawl.

1.3. Agriculture and Forestry Management

LULC studies support the management of agricultural and forestry resources by identifying suitable land for cultivation, assessing soil quality and monitoring forest cover changes. This information is vital for ensuring food security and sustainable forest management (Tripathi *et al.*, 2020).

Fig. 1. Importance of LULC Studies

1.4. Disaster Management and Risk Assessment

LULC data is critical for assessing the risk of natural disasters such as floods, landslides and wildfires. By understanding land use patterns and changes, planners can develop more effective disaster management strategies.

2. Technological Advancements in LULC Mapping

Technological advancements have significantly transformed Land Use and Land Cover (LULC) mapping, making it more accurate, efficient, and accessible (Macarringue *et al*., 2022). Here are some key technological advancements in LULC mapping:

2.1. Remote Sensing

The use of satellite imagery and aerial photography has revolutionized LULC mapping. Remote sensing allows for the collection of data over large areas, providing detailed information on land cover and land use changes. Techniques such as multispectral and hyperspectral imaging have improved the accuracy and detail of these maps.

2.2. Geographic Information Systems (GIS)

GIS technology enables the integration, analysis and visualization of spatial data. It allows for the creation of detailed LULC maps and supports spatial analysis to understand patterns, trends and relationships in land use data.

2.3. Global Positioning Systems (GPS)

GPS technology has improved the accuracy of field data collection and enabling precise mapping of land use features. GPS is often integrated with GIS for real-time data collection and mapping.

2.4. Drones and UAVs

Unmanned Aerial Vehicles (UAVs) or drones have become increasingly popular for LULC mapping. They provide high-resolution imagery at a lower cost and with greater flexibility compared to traditional aerial photography.

Classification of Land Use and Land Cover

The classification of Land Use and Land Cover (LULC) is essential for understanding how different land areas are utilized and the types of natural or human-made features they contain. These classifications can vary in detail depending on the scale and purpose of the study, but generally, they are grouped into broad categories that distinguish between natural and anthropogenic (human-made) features. Below are common classifications of LULC:

I) Types of Land Use

Land use can be classified into several categories based on human activities including:

- ***Agricultural Land Use*****:** This includes areas used for crop production, livestock grazing, orchards and plantations.
- ***Residential Land Use*****:** Areas used for housing and residential communities including urban, suburban and rural settlements.
- ***Commercial and Industrial Land Use*****:** This category includes areas used for business, manufacturing, warehouses and other industrial activities.
- ***Recreational Land Use*****:** Areas designated for parks, sports fields and other recreational activities.
- ***Conservation and Protected Areas*****:** Land set aside for wildlife conservation, nature reserves and national parks.

II) Types of Land Cover

Land cover refers to the physical material present on the surface of the earth, encompassing both natural and man-made features. Different types of land cover are classified based on their physical characteristics and the ecosystems they represent. Here are the main types of land cover:

- ***Forests*****:** Areas dominated by trees, including tropical rainforests, temperate forests and boreal forests.
- ***Grasslands*****:** Regions covered by grasses, including prairies, savannas and steppes.
- ***Wetlands*****:** Areas where water is the dominant factor in determining the types of plants and animals present, including marshes, swamps and bogs.
- ***Urban Areas*****:** Built-up regions with human-made structures, including cities, towns and infrastructure.
- ***Water Bodies*****:** Natural or artificial water features including rivers, lakes, oceans and reservoirs.

III) Classification Systems

Several classification systems are used to categorize land use and land cover:

- ***Anderson Classification System*****:** Developed by the US Geological Survey (USGS), this system classifies land use and land cover at various levels of detail from general categories like urban or agricultural to more specific types like residential or commercial areas.

- ***CORINE Land Cover (CLC)*****:** A European system that provides a standardized classification for land cover across Europe used in environmental and spatial planning.
- ***FAO Land Cover Classification System (LCCS)*****:** Developed by the Food and Agriculture Organization (FAO) this system is designed for global use and provides a flexible framework for classifying land cover types based on a standardized nomenclature.

3. Methods for LULC Mapping

LULC mapping involves various techniques that can be applied individually or in combination to achieve accurate and detailed land use and land cover classification. The methods range from remote sensing technologies to field surveys, and their integration is crucial for producing comprehensive LULC maps.

3.1. Remote Sensing Techniques

Remote sensing involves the acquisition of information about the Earth's surface through satellite imagery or aerial photography. Key techniques include:

- ***Multispectral and Hyperspectral Imaging*****:** These techniques capture data across different wavelengths of light, providing detailed information on land cover types and conditions.
- ***Synthetic Aperture Radar (SAR)*****:** SAR uses radar signals to create images of the Earth's surface, useful for mapping land cover in regions with cloud cover or in darkness.
- ***LiDAR (Light Detection and Ranging)*****:** LiDAR uses laser pulses to measure distances to the Earth's surface, creating detailed topographic maps and 3D models of land cover.

3.2. Geographic Information Systems (GIS)

GIS is a computer based tool for mapping and analyzing spatial data. It allows for the integration of various data sources including remote sensing images, topographic maps and field surveys to create detailed LULC maps. GIS supports spatial analysis such as change detection, pattern recognition and statistical modelling.

3.3. Field Surveys

Field surveys involve the direct collection of data on the ground. This method is often used to validate remote sensing data and to collect detailed information on specific land use and land cover types. Field surveys can include the use of GPS for accurate location mapping and the collection of environmental data such as soil type and vegetation cover.

3.4. Integration of Methods

Modern LULC studies often involve the integration of remote sensing, GIS and field surveys to create more accurate and comprehensive maps. This multi-method approach allows for the validation and cross-referencing of data, improving the accuracy and reliability of LULC assessments.

Applications of LULC Studies

Land Use and Land Cover (LULC) studies have a wide range of applications across various fields, including environmental management, urban planning, agriculture and climate science. These studies provide essential data for understanding and managing the earth's resources and environments. Here are some key applications of LULC studies:

- ***Environmental Monitoring*****:** LULC data is essential for monitoring environmental changes such as deforestation, desertification and habitat loss. It helps in understanding the impacts of these changes on biodiversity, climate and ecosystem services.
- ***Urban Planning and Development*****:** LULC studies provide crucial information for urban planning including land availability, infrastructure needs and environmental impacts. Planners use LULC data to design sustainable cities, manage urban sprawl and develop zoning regulations.
- ***Agriculture and Forestry Management*****:** LULC data supports agricultural planning by identifying suitable land for cultivation, assessing soil quality and monitoring crop patterns. In forestry, LULC studies are used to manage forest resources, track deforestation and plan reforestation efforts.
- ***Disaster Management and Risk Assessment*****:** LULC maps are critical for assessing the risk of natural disasters such as floods, landslides and wildfires. By analyzing land use patterns and changes, planners can develop more effective disaster management strategies and reduce vulnerability.

4. Challenges in LULC Mapping and Analysis

LULC mapping and analysis face several challenges that can impact the accuracy, reliability, and application of the results. These challenges are rooted in data limitations, environmental variability, and policy-related issues. Below are the key challenges categorized into specific areas:

4.1. Data Availability and Accuracy

One of the major challenges in LULC studies is the availability and accuracy of data. Remote sensing data may be limited by spatial resolution, temporal frequency and cloud cover. Moreover, data from different sources may have varying levels of accuracy, requiring careful validation and integration (Nedd *et al*., 2021).

4.2. Temporal and Spatial Resolution

The temporal and spatial resolution of remote sensing data is crucial for capturing LULC changes. High-resolution data may not be available for all regions or time periods, limiting the ability to detect fine scale changes or monitor rapid developments.

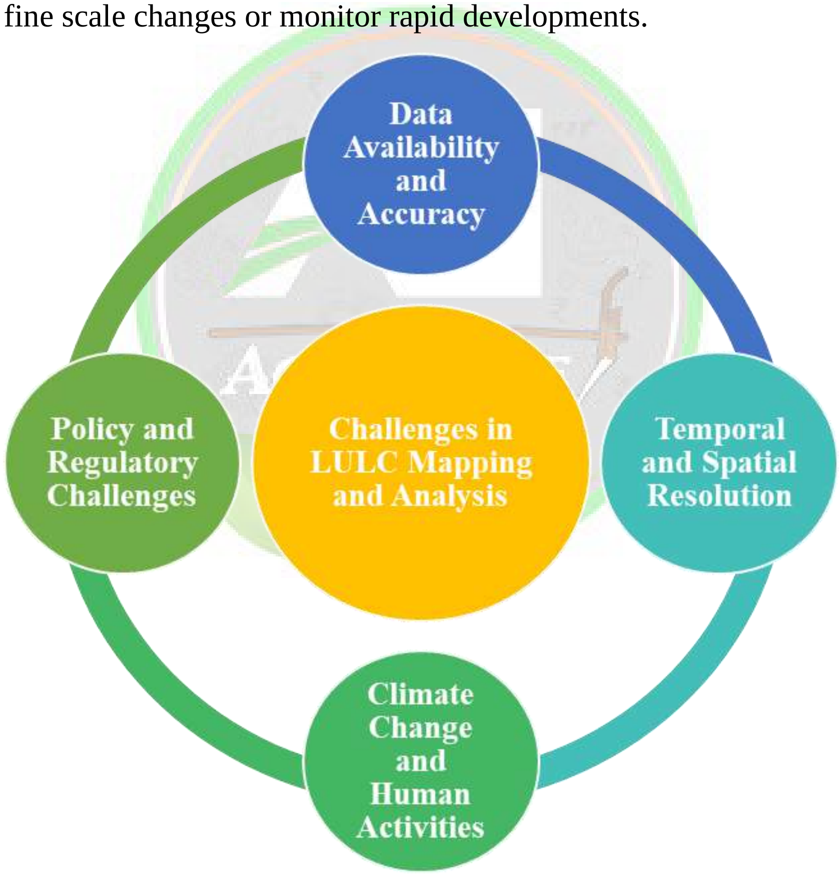

Fig. 2. Challenges in LULC Mapping and Analysis

4.3. Climate Change and Human Activities

Climate change and human activities significantly impact LULC patterns making it challenging to predict future changes. These factors can also lead to rapid and unpredictable changes in land use requiring frequent updates to LULC maps.

4.4. Policy and Regulatory Challenges

Implementing LULC policies requires coordination between various stakeholders including government agencies, landowners and conservation groups. Regulatory challenges arise when policies conflict with economic development goals or when there is a lack of enforcement mechanisms.

5. Future Perspectives

The future of Land Use and Land Cover (LULC) studies is promising, with significant advancements expected in technology, global collaborations, and sustainable land management practices. These developments will enhance our ability to monitor, analyze, and manage land resources more effectively and sustainably.

5.1. Advances in Technology

The future of LULC studies will be shaped by advances in technology including higher resolution satellite imagery, improved GIS capabilities and the increasing use of drones and UAVs. These technologies will enable more accurate and timely monitoring of land use changes, providing critical data for environmental management and policy-making.

Fig. 3. Future Perspectives

5.2. Global Initiatives and Collaborations

Global initiatives such as the United Nations' Sustainable Development Goals (SDGs) and the Paris Agreement on climate change emphasize the importance of sustainable land management. International collaborations and data-sharing initiatives will be crucial for advancing LULC studies and addressing global environmental challenges.

5.3. Sustainable Land Management

Sustainable land management practices will be essential for balancing development needs with environmental conservation. LULC studies will play a critical role in identifying sustainable land use strategies, protecting natural resources and promoting biodiversity.

Conclusion

Land Use and Land Cover (LULC) studies are integral to understanding the dynamic relationship between human activities and the natural environment. As the world faces increasing environmental challenges such as climate change, deforestation, and urbanization, LULC studies provide essential insights for sustainable development and conservation. The integration of advanced technologies such as remote sensing and GIS along with collaborative global efforts will be key to advancing our understanding and management of land resources in the future.

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IMPACT OF WEED MANAGEMENT IN MILLETS

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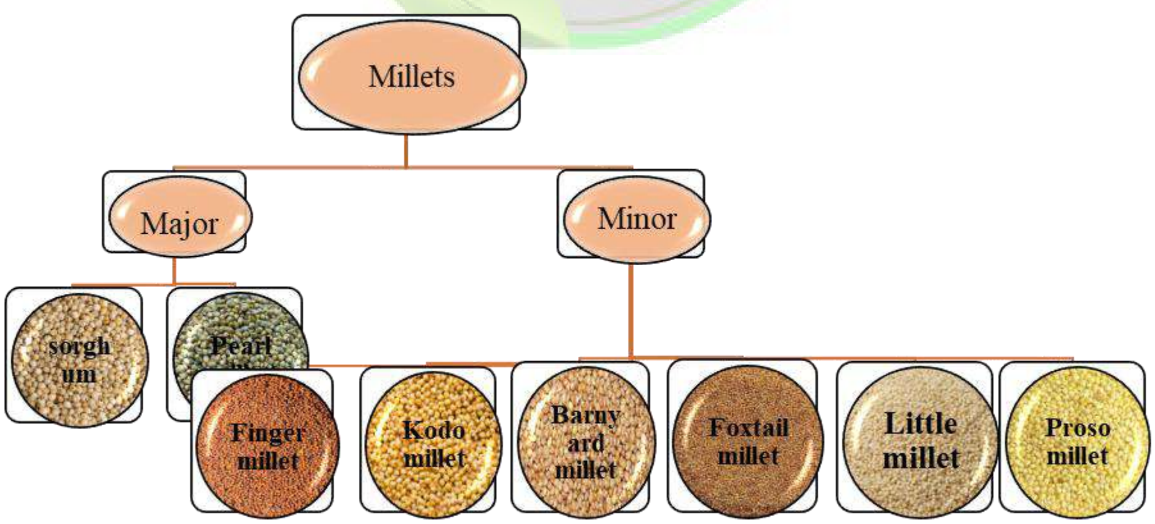
Introduction

Food and Agriculture Organization and United Nations has recognized 2023 as International Year of Millets or IYM 2023 for awareness about health and nutritional benefits of millets. The Indian Government proposed to celebrate 2023 as International Year of Millets. Millets are small-grained cereals that are grown with little input mostly under unfavorable agricultural situations. These crops mainly originated in Africa and Eurasia and were later domesticated in many other countries. Millets are an important staple in the semi-arid tropics and ensure food and nutritional security for poor people, who cannot cultivate other major food crops due to low rainfall and poor soil fertility.

Classification of millets



Millets are climate resistant crops and they may play an important role in reducing greenhouse gases by mitigating emission of nitrous oxide into the environment. The government of India has approved 2018 as the National Year of Millets to boost production of the nutrients-rich millets and the agro-industries involved in its production.

1) **MAJOR MILLETS**

- **Sorghum**
  - *Sorghum bicolor*
  - Also known as Great millet, Jonna, Jwari, Jowar.
- **Pearl millet**
  - *Pennisetum glaucum*
  - It is a huge source of protein
  - It is locally known as Bajara.

2) **MINOR MILLETS**

- **Finger Millet**
  - *Eleusine coracana*
  - It is a staple that is a substitute for oats and cereals.
  - It is Locally known as **Nagali.**
- **Kodo millet**
  - *Paspalum scrobiculatum*
  - It is locally known as **Kodara.**
- **Barnyard Millet**
  - *Echinochloa crusgalli*
  - It is a great source of iron and fiber.
  - It is locally known as **Samo.**
- **Foxtail Millet**
  - *Setaria italica*
  - It is abundant in minerals and vitamins.
  - It is locally known as **Kang**.
- **Little Millet**
  - *Panicum sumatrense*

- It is great source of iron and fibre.
- It is locally known as **Vari**.

➢ **Proso Millet**

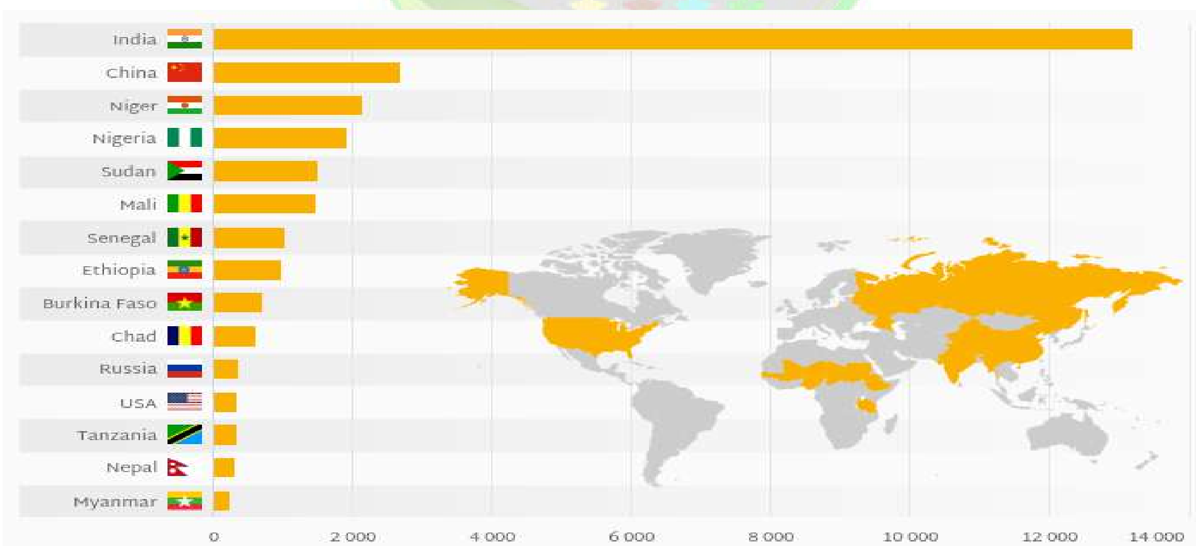
- *Panicum miliaceum*
- It is locally known as **Chino.**

❖ **Table 1. Crop-wise production area of millet in India (in million hectare)**

Year	Sorghum	Pearl millet	Finger millet	Other millets
2014-2015	5.45	7.32	1.21	0.59
2015-2016	4.57	7.15	1.14	0.65
2016-2017	5.62	7.46	1.02	0.62
2017-2018	4.90	7.10	1.20	0.50
2018-2019	4.01	6.7	0.95	0.49
2019-2020	4.48	6.77	0.97	0.46
2022-2023 (Estimate)	7.08	8.48	1.50	0.92

Anon. 2016

Top 15 millets producing countries in world



Millet production (kt), 2023 **Anon. 2023**

Table 2. Nutritive value of millets (per 100 g)

Crop	Protein (g)	Carbohydrate (g)	Fat (g)	Crude fibre (g)	Mineral matter (g)	Calcium (mg)	Phosphorous (mg)
Sorghum	10.4	72.6	1.9	1.6	1.6	25	222
Pearl millet	11.6	67.5	5.0	1.2	2.3	42	296
Finger millet	7.3	72.0	1.3	3.6	2.7	34.4	283
Proso millet	12.5	70.4	1.1	2.2	1.9	14	206
Foxtail millet	12.3	60.9	4.3	8.0	3.3	31	290
Kodo millet	8.3	65.9	1.4	9.0	2.6	27	188
Little millet	8.7	75.7	5.3	8.6	1.7	17	220
Barnyard millet	11.6	74.3	5.8	14.7	4.7	14	121

Anon. 2017

❖ **Benefits of producing millets to farmers**

- Short cropping season
- Ability to grow in poor soils and deficient rainfall
- Minimal requirement of chemical fertilizers or pesticides
- Low investment, easy storage and prolonged shelf life
- Offering a variety of economic benefits such as assured income and sustainable livelihood

❖ **Health benefits to consumers**

- Millets are rich in antioxidants and micronutrients
- Improve digestion
- Help in weight loss
- Boost immunity
- Detoxify the body

- Niacin (vitamin B_3) in millet can help to lowering cholesterol
- Control diabetes

❖ Weed problem in millets

- Any undesirable or troublesome plant, especially one that grows abundantly where it is not wanted is known as weed.
- Weeds compete with crops for space, soil nutrients, water and light. They host insects and plant pathogens harmful to crop plants and their root exudates and leaf leachates may be toxic to crop plants. Weeds also hinder crop harvest and increase the costs of such operations.
- **Major weeds of millet**

Cyperus rotundus (Chidho)

Cynodon dactylon (Dharo)

Convolvulus arvensis (Noli)

Amaranthus viridis (Tandalajo)

Sorghum halepense (Baru)

Dactyloctenium Aegyptium (Chokadiyu)

Striga litura (witchweed)

Trianthema - Portulacastrum (Satodi)

- In addition, at harvest weed seeds often contaminate the crop produce. Thus, the presence of weeds in crop areas reduces the efficiency of inputs such as fertilizer and irrigation water, enhances the density of other pest organisms and finally severely reduces crop yield and quality.

- In millets, heavy infestation of complex weed flora especially during rainy season causes 15-83% reduction in yield.
- To reduce the loss of crop yield and quality, proper weed management is necessary.

Critical period of crop-weed competition in millets

Crops	Critical periods (Days after sowing)
Sorghum	28–42
Pearl millet	15-30
Finger millet	25–42
Kodo millet	25-40
Barnyad millet	15-42
Foxtail millet	20-35
Little millet	20-30
Proso millet	15-42

Dubey *et al.* (2023)

The critical period of weed competition is the period of time in which weed control is necessary to avoid significant yield loss (Nazarko *et al.*, 2005). It is time span in the growth cycle of crop growth when weeding with result in highest economic returns. In millets, Because of the slow initial growth, early 30 days period are more critical for weed competition.

Integrated weed management

IWM is the rational use of direct and indirect control methods to provide cost-effective weed control. Such an approach is the most attractive alternative from agronomic, economic and ecological point of view. Among the commonly suggested indirect methods are land preparation, water management, plant spacing, seed rate, and cultivar use and fertilizer application. Direct methods include manual, cultural, mechanical, chemical and biological methods of weed control.

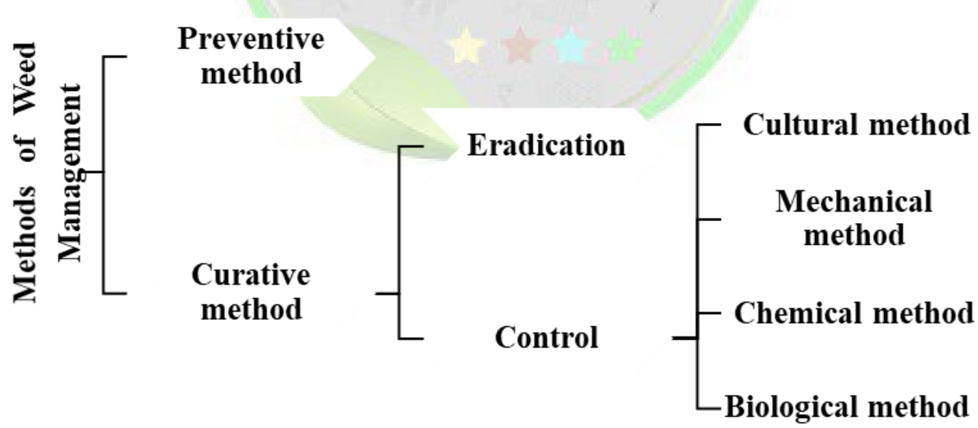
The essential factor in any IWM programme is the number of direct and indirect methods that can be combined economically in a given situation. For example, increased frequency of ploughing and harrowing does not eliminate the need for direct weed control. Therefore, it is more cost-effective to use fewer pre-planting harrowing and combine them with direct weed control methods.Integrated weed management is an approach to managing weeds using multiple control tactics.

An IWM involves the utilization of a combination of cultural, mechanical, chemical and Biological practices of weed management in a planned sequence, designed in such a way that not affect the ecosystem. The purpose of IWM is to include many methods in a growing season to allow producers the best chance to control troublesome weeds. Integrated weed management (IWM) approach aims at minimizing the residue problem in plant, soil, air and water.

The nature and intensity of the weed to be controlled, based on the sequence of crops that are raised in the rotation, the standard of crop husbandry, the ready and timely availability of any method and the economics of different weed-management techniques.

- **Why IWM is Necessary?**
  - One method of weed control may be effective and economical in a situation and it may not be so in other situation.
  - No single herbicide is effective in controlling wide range of weed flora.
  - Continuous use of same herbicide creates resistance or shift in the weed flora.
  - Continuous use of only one practice may result in some undesirable effects.
  - Only one method of weed control may lead to increase in population of particular weed.
  - Indiscriminate herbicide use and its effects on the environment and human health..
  - The continuous use of the same method leads to build up of tolerant weeds.
  - Weed can be controlled by adopting different methods however, each weed control methods has advantages and disadvantages or limitations.

- **Methods of weed management**



A. **Preventive method**

We all are familiar with the proverb often used in weed control **"One-year seeding, seven years weeding."** Nature has equipped the weeds with immense potential to be well disseminated through various means and thrive well in various drastic and unfavorable environmental conditions. As we know that **"Prevention is better than cure"** so it is better to prevent the weed species to spread in the croplands and infest the crop. **Prevention simply means stopping weeds from infesting an area.** Prevention requires a set of practices rather than a single practice to tackle the introduction and spread of weeds. Such areas may be local, regional or national in size. No weed control programme is successful if adequate preventive measures are not taken to reduce weed infestation. It is a long term planning so that the weeds could be controlled or managed more effectively and economically than is possible where these are allowed to disperse freely.

➢ **The strategies follows in preventive method**

- Use of clean seed
- Use of clean farm equipment's
- Clean water courses and irrigation canals
- Ensure that farmyard manure free from weed
- Control grazing of livestock
- Prevent the formation of weed seeds or vegetative progules
- Legal measures
- Adopt specific measures when harvesting weed-infested crops.

B. **Curative method**

❖ **Eradication**

Weed eradication is complete removal of all live plant parts and seeds of a weed from an area & that weed will not reappear unless reintroduced to the area. It is a very expensive method because often cost more than the land worth. Moreover, total destruction of weeds is considered undesirable even from crop fields because, many weeds provide habitat to predators of crop pests Secrete nematicides in soil Weeds hold soil nutrients against leaching losses during fallow periods. Heavy expense of weed eradication is justified against noxious weeds such as *Striga*, *Cuscuta* and *Lantana* spp., and some perennial weeds likes *Cyprus rotundus, Cynodon devtylon*, *Convolvulus arvensis*, *Circium arvense* etc. to prevent their dispersal to additional millions of hectares of useful land and water bodies.

❖ **Control**

It includes those processes where by weed infestations are reduced but not necessarily eliminated. It is ranging from poor to excellent. In control methods, the weeds are occasionally killed but their growth is severely restricted, the crop makes a normal yield. In general the degree of weed control obtained is dependent on the characters of weeds involved and the effectiveness of the control method used like as a Cultural, Physical, Chemical and Biological.

- **Cultural Methods**

It is a fundamental method of weed management. Cultural weed management techniques are of immense importance in crops where other weed management options are limited or not available. Cultural weed management is an important part of nearly all weed management systems. **Cultural weed control refers to any technique that involves maintaining field conditions such that weeds are less likely to become established and increase in number**. The techniques of cultural weed control are well known to farmers and weed scientists.

  - Field preparation, Summer tillage, Maintenance of optimum plant population, Crop rotation, Growing of intercrops, Mulching, Solarisation, Stale seedbed, Blind tillage, Crop management practices, Proper placement of fertilizers, Better irrigation practices, Fast growing crop varieties, Higher plant population per unit area results in smothering effect on weed growth

- **Physical Method**

The physical method of weed control is the mechanical method of weed removal from the field which is often adopted in millets. This is one of the effective methods of weed control that ensure complete control of weeds during the desired period of crop growth. Weeds are abundant seed producers. The seeds fall on the ground and remain dormant for days to years and germinate when favorable environment appears. Several weeds propagate through vegetative propagules such as swollen roots, rhizome and bulbs which remain inside the soil and help the weeds to survive year after year in the field. The mechanical method of weed control helps in suppressed weed seed as well as the removal of weed plant and vegetative propagules from the soil of the cultivated field which reduces the weed thrust in the field eventually reducing the crop-weed competition and enhancing the crop yield.

Growers can incorporate this tactic by:

1. Tillage, Inter-cultivation, Hand weeding, Mowing, Hoeing, Digging, Burning, Robotic weeding machines, Flooding

- **Chemical method**

Chemicals that are used to kill weeds are called herbicides. Herbicides are an important part of most weed management plans and will continue to be so, even in IWM programs.

Good management practices for applying herbicides include:

1) Timely scouting, Proper weed identification and awareness of what herbicide- resistant weeds are in the area, correct herbicide application, meaning applying the appropriate product at the right rate and at the right time, Maximized diversity through the use of tank mixes herbicides with different, effective sites of action (SOA) and by rotating herbicides throughout the season whenever possible.
2) Plan ahead across seasons to avoid using herbicides with the same sites of action frequently.

- Commonly used herbicides in millets
- ✓ Atrazine, Pendimethalin, 2,4-D, Oxyfluorfen, Butachlor, Pyrazosulfuron, Metsulfuron
- ✓ Bensulfuron-methyl + pretilachlor, Isoproturon, Pretilachlor

- **Harmful effect of herbicide**
  - ✓ On Vegetation/ weed flora
    - Toxicity to plants by herbicides residues
    - Shifts in weed flora
    - Resistance against herbicides in some weeds
  - ✓ On Environment
    - Lethality in natural predators
    - Shifts/ induce in soil microbes
    - Contamination of water bodies
  - ✓ On Livestock/ fisheries
    - Toxic diseases in animals
    - Toxicity leading to death of aquatic life
    - Damages to wildlife
  - ✓ On Human health
    - Embryonic malformations
    - Reproductive disorders
    - Loss of immunity upon intake of herbicide contaminated food
    - Liver and kidney malfunctions

- **Biological method**

Use of living organisms viz., insects, disease organisms, herbivorous fish, snails or even competitive plants for the control of weeds is called biological control.

Biological agent	Weed
Dacrtylopies ceylonicus	Prickly pear
Neochetina eichhorniae *Neochetina bruchi*	Water hyacinth
Zygrogramma bicolorata	Parthenium
Teleonemia serapora	Lantana camara
Cryptobagous salvinae	Water fern

- **Advantages of IWM**
  - It shifts the crop – weed competition in favour of crop.
  - Prevents weed shift towards perennial nature.
  - No danger of herbicide residue in soil or plant.
  - Prevents resistance in weeds to herbicides & No environmental pollution
  - Gives higher net return & Suitable for high cropping intensity.

Conclusion

Slow initial growth and wider spacing were the major reasons for severe crop weed competition in millets. In general, 20-35 DAS was the critical period for crop weed competition in millets. Instead of relying on any single method of weed control. Integrated weed management in millets is a multifaceted approach that combines various methods such as cultural, mechanical, chemical and biological strategies to effectively control weeds while minimizing the negative impacts on millet crops and the environment. All the feasible methods are to be integrated for the effective and sustainable management of weeds in millets IWM can effectively overcome the problems of weed shift and development of resistance in weeds and reduce the weed density and manage the weeds below the economic threshold level to avoid any economic loss.

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BIO FERTILIZER – AN UNDERRATED SOIL HEALTH ENHANCER

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Abstract

Natural fertilisers called biofertilizers, which increases the amount of nutrients available to plants by using living microbial inoculants like bacteria, algae, or fungi, either separately or in combination. The use of biofertilizers in agriculture is becoming increasingly important, especially given the current environment of rising chemical fertiliser costs and their detrimental impacts on soil health. The use of bio-fertilizers offers many benefits for farmers and gardeners. By improving soil health, increasing crop yields, enhancing soil fertility, reducing environmental impact, and being cost-effective, bio-fertilizers are a sustainable and eco-friendly option for fertilizing crops and gardens. As the demand for organic and sustainable agriculture continues to grow, the use of bio-fertilizers is likely to become even more widespread, helping to support the health of our soils, crops, and planet.

Key words: Bio fertilizer, Bacteria, Sustainable Agriculture, Nutrient management, Soil health

Introduction

Biofertilizers are defined as formulations that contain active or dormant cells of effective strains of microorganisms that, when applied as soil or seed, aid in the rhizosphere's interactions with crop plants to facilitate the uptake of nutrients. They quicken some microbial activities in the soil that increase the amount of nutrients available in a form that is simple for plants to absorb. Since microorganisms are frequently not as effective in their natural environments as one would think, artificially reproduced cultures of effective microorganisms that have been chosen play a crucial role in quickening the microbial activities in soil. Since biofertilizers are an affordable and sustainable source of plant nutrients to augment chemical fertilizers for sustainable agriculture, their use is a crucial part of integrated nutrient management. These are just a handful of the benefits of applying bio-fertilizers.

Better soil health: One of the key advantages of using biofertilizers is that they can make the soil healthier. Bio-fertilizers can help to improve soil structure, boost nutrient availability, and improve the soil's capacity to hold moisture by introducing helpful microbes into the soil. Better agricultural yields, more sustainable farming methods, and healthier plants can result from this.

Crop yields can be raised with the aid of bio-fertilizers: Bio-fertilizers can increase plant production and health by giving plants the nutrients they require to develop and thrive. Crop yields can also be further increased by using the advantageous microorganisms found in biofertilizers to shield plants from pests and illnesses.

Enhanced long-term soil fertility: Biofertilizers have advantages for the soil that extend beyond their immediate application. Bio-fertilizers have the potential to improve soil health and foster a more diversified and healthy soil ecosystem by introducing beneficial microorganisms into the soil. Future agricultural output improvements and more environmentally friendly farming methods may result from this.

Minimized environmental impact: One more benefit of employing biofertilizers is their significantly smaller environmental impact as compared to synthetic fertilizers. Because bio-fertilizers are natural products, they don't pollute water or the environment or release dangerous chemicals into the air or water. They also don't cause soil erosion. They are therefore a more environmentally friendly and sustainable choice for farmers and gardeners.

Cost-effectiveness: Bio-fertilizers are also generally more cost-effective than synthetic fertilizers. Since they are made from natural materials, they are often less expensive to produce, and they can be applied to the soil at a lower cost. This can help to reduce the overall cost of fertilization and make it more affordable for farmers and gardeners.

Different types of Bio fertilizers

The manufacturing of biofertilizers makes use of a number of microorganisms and their relationships with agricultural plants. Depending on their nature and purpose, they can be categorized in a variety of ways.

I. Symbiotic:

Symbiotic nitrogen fixers reduce nitrogen in association with plants by forming some specialized structures in plants.

a) **Legume – rhizobium symbiosis**:

Some plants of Leguminosae family form a symbiotic association with bacteria with the genus *Rhizobium* which fix atmospheric nitrogen. *Rhizobia* infect the root moving to the root cortex through an infection thread which results in the formation of a tiny outgrowth called root nodule. *Sesbania rostrata* forms nodules on the stem as well. This association is host specific. The *Rhizobia* turn to bacteroids which have nitrogenase enzyme embedded into leg-hemoglobin.The symbiotic association of the host and the bacterium is mutually beneficial to both organisms. Specific species of bacterium infects the roots of a particular group of legumes. This host specificity of different *Rhizobium* species or the group of legume crops nodulated by single *Rhizobium* sp. is referred to as cross inoculation group .

Rhizobium sp.	Plants nodulated
R. meliloti	*Medicago sativa* (alfalfa), *Melilotus* sp. (sweet clover), *Medicago* sp., *Trigonellafoenum grakum* (fenugreek)
R. trifolii	*Trifolium*sp. (red clover, white clover)
R. leguminosarum	*Pisum sativum* (garden and field peas), *Viciafaba* (broadbean), *Lens esculenta* (lentils), *Lathyrus* sp.
R. phaseoli	*Phaseolus vulgaris*, *P. coccineus*
R. lupini	*Lupinus sp., Ornithopus sativus*
R.japonicum	*Glycene max* (soybean)
Rhizobium sp.	*Vigna ungiculata* (cow pea), *V. radiata* (mung bean), *Arachis hypogeae* (groundnut), *Cajanus cajan* (redgram) *Cicer arietinum* (chickpea), *Sesbania sp*.

Symbiosis with non-legumes

i) Non legume – *Frankia* symbiosis

The member actinomycetes, the *Frankia* forms symbiosis with forest trees belonging to the families *Casuarinaceae* and *Myricaceae*.

ii) Azolla – Anabaena symbiosis:

Azolla is a fresh water fern found floating on the surface of water. All the species of *Azolla* have an algal symbiont called *Anabaena azollae* in a specialized cavity in the upper leaf surface. In rice fields the symbiosis can fix N_2 up to 30-40 kg N ha^{-1}.

iii) Nonspecific associative N2 fixers:

Rhizobacteria like *Azospirillum*, *Acetobacter*, *Azotobacter*, *Flavobacterium*, *Pseudomonas* etc. These bacteria are capable of using exudates of roots as the source of energy.

Azofication: Heterotrophic free-living bacteria *Azotobacter and Clostridium* fix N referred to as Azofication. These organisms derive energy from the decomposing organic

II. phosphate solubilizing bacteria (PSB).

Beneficial bacteria with the ability to dissolve inorganic phosphorus from insoluble substances are known as phosphate solubilizing bacteria (PSB). One of the key characteristics linked to plant phosphate nutrition is thought to be the rhizosphere bacteria' capacity to solubilize phosphate. Several soil bacteria and fungi, notably species of *Pseudomonas, Bacillus, Penicillium, Aspergillus etc*. It is widely acknowledged that the process by which PSB strains solubilize mineral phosphate is linked to the release of low molecular weight organic acids. This is because the hydroxyl and carboxyl groups of these acids chelate the cations, or positive-charged ions, attached to phosphate, transforming it into soluble forms. As phosphate biofertilizer, PSB have been presented to the agricultural community.

III. AM Fungi

Intracellular obligate fungal endosymbionts belonging to the genera Glomus, Gigaspora, Acaulospora, Sclerocysts, and Endogone facilitate the transfer of nutrients, primarily phosphorus, zinc, and sulphur, from the soil *milleu* to the cells of the root cortex. These endosymbionts have vesicles that store nutrients and arbuscles that direct these nutrients into the root system. Of all the genus, Glomus seems to be the most prevalent; its various species are found in soil. Large-scale production is hampered by the lack of pure cultures of Arbuscular Mycorrhiza (AM) fungi, even though studies in the lab have consistently demonstrated the positive effects of AM fungal inoculation on plants, particularly when combined with other nitrogen fixers.

IV. Silicate Solubilizers

Silicates and aluminium silicates can be broken down by microorganisms. Numerous organic acids are created by bacteria during their metabolism, and these acids have two roles in the weathering of silicate. They provide the medium with H+ ions and encourage hydrolysis. Additionally, they support the elimination of complexes with cations and their retention in the medium in a dissolved state for organic acids such as citric, oxalic, keto, and hydroxy carbolic acids. The bacterial isolates made from different locations had varying degree of silicate solubilizing potential. Soil inoculation studies with selected isolate with red soil, clay soil, sand and hilly soil showed that the organisms multiplied in all types of soil and released more of silica and the available silica increased in soil and water.

V. Plant growth promoting rhizobacteria

Plant growth promoting rhizobacteria are a kind of bacteria that are good for crops and that inhabit roots or rhizosphere soil (PGPR). Presently available commercial PGPR inoculants appear to stimulate growth by a minimum of one mechanism: phytohormone synthesis (called Bio stimulants), enhanced nutrient uptake (called Biofertilizers), or inhibition of plant disease (called Bioprotectants). Certain Pseudomonas and Bacillus species have the ability to create phytohormones or growth regulators that, although not fully understood, cause crops to have more fine roots. This increases the plant roots' absorptive surface area, which increases the roots' ability to absorb water and nutrients. The phytohormones that these PGPR, also known as bio stimulants, generate include gibberellins, cytokinins, indole-acetic acid, and inhibitors of ethylene synthesis.

Conclusion

In conclusion, Biofertilizers have not been widely used in agriculture, despite encouraging results. This is mostly due to the fact that plant genotypes and species respond differently to inoculation, depending on the bacterial strain employed. On the other hand, a bacterial strain's success as an inoculant is mostly determined by its high saprophytic competence and strong competitive capacity. To obtain effective inoculants, research into the persistence and synergistic activities of particular microbial populations in complex settings, including the rhizosphere, is necessary.

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EXPLORING THE VERSATILE POTENTIAL OF CASTOR PLANT PARTS

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Abstract

The castor plant (*Ricinus communis L.*) is a versatile oilseed crop recognized for its economic importance of seeds, leaves and roots. Castor leaves are utilized as feed for eri silkworms, possess medicinal properties and exhibit potential in bioremediation, effectively removing pollutants and enhancing soil health. Additionally, castor roots interact with soil microbial communities to improve nutrient availability and demonstrate resilience in contaminated environments, making them suitable for phytoremediation. The seeds contain 48-52% oil, predominantly ricinoleic acid, making them valuable for industrial applications such as lubricants, biodiesel and the production of chemicals like sebacic and undecylenic acids. The castor cake, a by-product of oil extraction, serves as a nutrient-rich organic fertilizer. Overall, the multifaceted uses of castor plant parts contribute to economic sustainability for farmers and promote environmentally friendly practices, highlighting the plant's significant potential in advancing both industrial and agricultural sectors.

Key words: Castor; leaves; roots; seeds; oil; pharmaceutical; phytoremediation;

Introduction:

Castor (*Ricinus communis L.*) is an oilseed crop belonging to the Euphorbiaceae family, characterized by its indeterminate growth. Castor bean is a great biofuel crop with a low water requirement, prolific growth, substantial oil output, the ability to tolerate extended periods of drought and the ability to grow well on degraded and marginal lands. Growth is suitable for both rainfed and irrigated condition along with a hot and humid climate. Currently, castor is grown in 30 countries of which India, China, Brazil, Mozambique, Ethiopia and Thailand being the primary producers, together contributing about 90 per cent of global output. India alone accounts for approximately 66.5 per cent of the world's castor cultivation area and 82.9 per cent of its production. Castor serves various purposes, including agricultural, energy, environmental and industrial applications. Although castor is non-edible, its various parts can be effectively utilized for multiple purposes. By leveraging all parts of the castor plant, farmers can enhance their income sustainability. Key parts of the castor plant, including the leaves, seeds and roots offer valuable utilization opportunities.

Potential of castor leaves:

Castor leaves (Fig. 1) are suitable for feeding eri silkworms in eri culture, which has been recognized as a beneficial supplementary occupation that provides additional income for many rural and tribal communities. A defoliation rate of up to 30% is acceptable, allowing for their use in eri culture without sacrificing economic yield. Additionally, farmers can earn an extra income of approximately Rs. 6,000 to Rs.7,500 per hectare through eri culture, making it a valuable opportunity for rainfed castor growers. Castor plants can function as trap crops for pest control. The foliar phenolics present in the castor leaf induce the antibiosis and the leaf phenolics are modified quantitatively due to pest feeding and further these enhanced phenolics have profound effects on feeding herbivore larval performance and mortality. This approach helps lower spraying costs, as pesticides are applied only to the castor plants when they are infested with *Spodoptera litura.* Castor leaf extract at concentrations of 5% and 10% has been shown to enhance mycelial growth, sporulation and propagule density of *Paecilomyces lilacinus* on tomato roots. This increase in fungal activity promotes better colonization of the bioagent on the roots, leading to increased parasitization of *Meloidogyne incognita* eggs. The aqueous extract of castor leaves inhibited the growth and germination of several weeds (*Glycine max, Carthamus* *tinctorius*). The castor leaves also has medicinal properties. The leaves contain various secondary metabolites which can be used in various pharmaceutical applications (Tab. 1) (Gopalakrishnan and Rampally, 2015)

Table 1. Phytochemical screening *Ricinus communis* Leaves

Test for phytoconstituents	**Water extract**	**Ethanol extract**
Test for Starch	+	+
Test for Terpenoids	+	+
Test for Proteins	+	+
Test for Mucilage	-	-
Test for Alkaloids	+	+
Test for Anthraquinone glycoside	+	+
Test for Cardiac glycoside	+	+
Test for Saponin	+	-
Test for Tannins	+	+
Test for Steroids	+	+
Test for Flavonoids	+	+
Test for phenols	+	+

The saponins and phenolics extracts have potential effect on the growth proliferation of the two pathogenic bacteria such as *Staphylococcus aureus* and *Klebsiella halize* (common symbiont bacteria that can become infectious once inside the human host). The leaves can be used in the treatments related to antiviral, biliousness, burns, ear and head ache, malaria and night blindness. The castor leaves can be used as an excellent biosorbent to remove mercury (II) from wastewaters with good efficiency and low cost. The safranin dye from textiles can be removed efficiently from water by applying a castor leaf-based biochar adsorbent synthesized by slow pyrolysis at high temperatures. The fibrous residues of castor leaves has its application in pulp and paper production. Decomposed castor leaves can enrich soil fertility when used as organic fertilizer, contributing to sustainable farming practices. In some cultures, the large, flexible leaves are utilized as biodegradable wrappers for food items, aligning with eco-friendly packaging alternatives. Overall, the diverse uses of castor leaves not only highlight their agricultural and medicinal significance but also emphasize their potential in promoting sustainable practices and enhancing the livelihoods of farmers.

Figure 1: Castor leaf

Potential of castor roots:

Castor roots interact with the rhizosphere microbial community, playing a crucial role in enhancing the bioavailability of nutrients in the soil. They benefit from these microbial populations by facilitating the recycling and solubilization of mineral nutrients and gaining an increased supply of metabolites, including growth-promoting phytohormones that stimulate plant growth. Moreover, castor plants demonstrate exceptional resilience, able to tolerate in challenging environments such as industrial waste-contaminated sites, roadsides, rail tracks and other disturbed areas. Their remarkable ability to withstand harsh conditions underscores their adaptability and ecological versatility, making them valuable candidates for phytoremediation efforts. The castor roots stimulate plant growth and alleviate metal toxicity (Fig. 2).

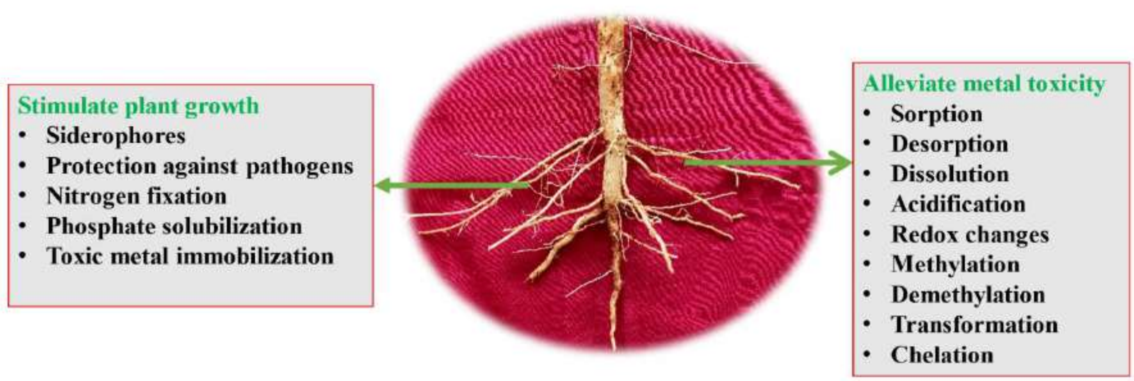

Figure 2: Stimulation of plant growth and alleviation of metal toxicity by castor roots

The castor plant exhibits a remarkable ability to thrive in environments affected by metalloids, organic pollutants, salinity, drought and coastal soils. This resilience is largely attributed to its extensive, deep root system, which allows it to absorb a greater volume of pollutants from contaminated soils while also helping to mitigate soil erosion caused by water. This unique adaptation not only enhances the plant's survival in challenging conditions but also contributes to soil stability and environmental remediation. It has been found that the castor is tolerant to heavy metals and is thus a candidate for the remediation of soils contaminated with multiple heavy metals (e.g. Cu, Cd). Its root act as a hyperaccumulator of lead. Castor root is also used as an ingredient of different prescriptions for nervous diseases and rheumatic affections. The aqueous extract of castor roots has the allelopathic effect on dodder plants (*Cascuta campestris*). As the castor roots consists of more tannin content than other parts it can be used in various industrial and pharmaceutical application (Fig. 3) (Alugah and Ibraheem, 2014).

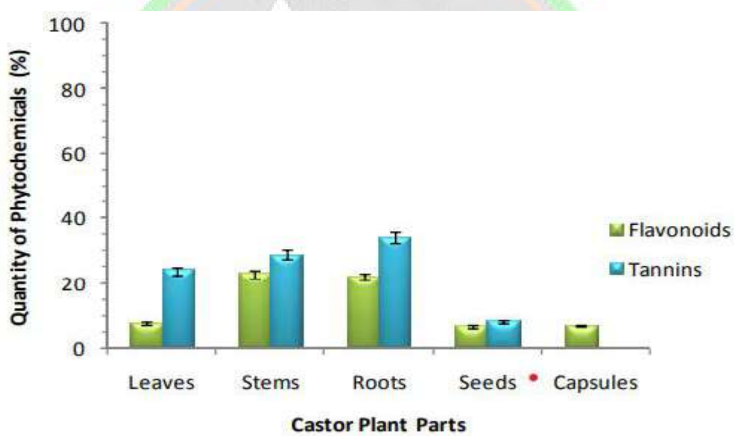

Figure 3: Flavanoid and tannin content in castor plant parts

Potential of castor seeds:

The castor seed (Fig. 4) is the primary economic product of the castor crop, containing 48-52 per cent of oil, which holds significant industrial value. This oil is notable for its unique chemical composition, primarily consisting of triglycerides, with around 90 per cent of its fatty acid chains being hydroxyl in nature, making it the only natural source of ricinoleic acid. Castor oil and its derivatives are widely utilized in various industrial applications, including lubricants, fuel additives, hydraulic fluids, brake fluids, pharmaceuticals, cosmetics, paints, dyes, coatings, inks, cold-resistant plastics, waxes, and polishes. Additionally, castor oil is employed in the production of hydraulic fluids, artificial leather, printing inks, rubber, recinol, soaps and greases, showcasing its versatility and broad applicability across multiple sectors. Castor oil serves as a crucial raw material for producing various chemicals, including sebacic acid, undecylenic acid, and nylon-11. In several countries, it is also viewed as a viable option for biodiesel production due to its high ricinoleic acid content, solubility in alcohol, and impressive conversion efficiency of 90–95 per cent. Additionally, the castor cake that remains after oil extraction can be utilized as an organic fertilizer. This cake is a rich source of concentrated organic manure, containing 6.6 per cent nitrogen (N), 2.6 per cent phosphorus (P_2O_5), and 1.2 per cent potassium (K_2O) from decorticated seeds and 4.5 per cent N, 0.7 per cent P_2O_5, and 1.9 per cent K_2O from undecorticated seeds. It is particularly beneficial in sugarcane cultivation, as it is resistant to white ant infestations (Ramanjaneyulu et al., 2013). Approximately 100 kg of castor cake can provide nitrogen equivalent to that from 1,800 kg of cow dung, making it a valuable resource for organic farming. Furthermore, castor cake can be applied to various soil types, enhancing microbial activity, promoting root development, and improving winter cold hardiness in plants.

Figure 4: Castor seed

Table 2: Castor plant parts and its potential

Castor plant parts	Potentiality
Castor leaf	• Eri silk Production • Trap for pests • Leaf extract – as pesticide • Pharmaceutical applications • Bio-adsorbent • Fibrous residue – for pulp and paper production • Decomposed plant residue – as manure

Castor root	• Stimulate plant growth • Alleviate metal toxicity • Pharmaceutical applications
Castor seeds	• Industrial applications • As raw material for producing various chemicals (sebacic acid, undecylenic acid, and nylon-11) • Biodiesel production • Cake is a rich source of concentrated organic manure

Conclusion

In conclusion, the castor plant exhibits remarkable potential across its various parts, making it a valuable resource for both industrial and agricultural applications. From its seeds, which are rich in oil and essential for the production of various chemicals and biodiesel, to its leaves and roots that contribute to sustainable farming practices and environmental remediation, each component plays a vital role. The versatility of castor plant parts not only enhances soil health through organic fertilizers but also supports economic sustainability for farmers. By fully harnessing the diverse benefits of the castor plant, we can advance industrial innovation while promoting ecological balance and sustainability, paving the way for a more resilient and productive agricultural landscape.

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FISHERY PROSPECTUS OF NORTH EAST INDIA

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Abstract

The North Eastern region of India, with its rich natural water resources and favourable climatic conditions, holds immense potential for fisheries development. Encompassing eight states Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura—the region is blessed with an abundance of rivers, lakes, wetlands, and floodplains, making it a hotspot for fishery activities. The region's diverse aquatic ecosystems, including the Brahmaputra and Barak river basins, support a wide variety of freshwater fish species. The climatic conditions and high rainfall promote the natural breeding of fish, contributing to the abundance of indigenous species like Catla, Rohu, Mrigal, and various species of carps. The extensive wetlands known locally as **beels** in Assam and ponds add to the potential for both capture and culture fisheries. The fishery sector in North East India faces challenges such as inadequate infrastructure, limited access to modern technology, and issues related to water pollution. However, government initiatives such as the Pradhan Mantri Matsya Sampada Yojana (PMMSY) aim to boost fish production by improving hatcheries, providing financial support, and promoting sustainable practices. Enhancing cold storage, transportation, and marketing networks is also crucial for expanding the region's fish trade to national and international markets.

Keywords: North East, River, Indigenous species, Aquatic ecosystem

Introduction:

The North East region has about 19,150 km of rivers; 23,972 ha. of reservoirs; 1,43,740 ha of lakes; 40,809 ha. The State Assam which forms about 30% of the North Eastern region has Brahmaputra and Barak river systems and their numerous tributaries (combined length 4820 km) and a large number of flood plain wet lands (Beel).Northeastern states are generally the sum of 7 states of India (Tripura, Manipur, Mizoram, Meghalaya ,Nagaland ,Assam and Sikkim) where they lacks costal area.

Diverisified Fishery in North East India:

The North East India is considered as one of the hot spots of fresh water fish biodiversity in the world. The North Eastern Region shares its fish fauna predominantly with that of the Indo-Gangetic fauna and to a small extent with the Burmese and South China fish fauna. The region has been ranked sixth among the top 25 biodiversity spots in the world. The mean temperature ranges from 18 degree C to 25 degree C and rainfall is 2000-4000 mm with local variations (1500-12000 mm). The soil type varies from high plains and plateaus to hills and mountains with pH varies from 4.5 to 6.5. These diverse and dynamic environmental conditions make the NE India a 'global hotspot' for aquatic biodiversity and hub for fisheries and aquaculture enhancement In this part freshwater aquaculture play lions share in the fish culturing field. Indian major carp (Rohu, Catla, and Mrigal) Chinese carp like common carp, grass carp, silver carp etc. Among the cold-water fisheries, Mahseer and Trout are also being cultured.

The northeast region of India with their diversified freshwater resources has several important fish species of ornamental value. About 80-85% fish fauna of this region can be accounted under the ornamental category. There are about 267 species belong to 136 genera of fresh water fishes inhabiting in Northeast India .Out of which, 54.32% possess either of the three values as food for human, complacent in tourism , aquarium fish trade, and are thus potential resources for the growth of economy. Aquarium fishes are categorized based On various color pattern (colorful), morphologically unique born and behaviorally charismatic. The current checklist of fishes of North East India showed 250 potential ornamental fish species, Out of this, the highest no. recorded from Assam (187), followed by Arunachal Pradesh (165), Meghalaya (159), Manipur (139), Tripura (103), Nagaland (71), Mizoram(46) and Sikkim(29).Fish species of northeast India can be considered as potential ornamental species at least in their early stages of life or during breeding season.

Major fish species cultured in northeast India:

STATES	FISH SPECIES
Assam	Rohu, Catla, Mrigal, Grass carp,Common carp
Arunachal Pradesh	Rohu,Mrigal,Silvercarp,Grasscarp,Commoncarp, Mahasheer,Trout
Nagaland	Rohu, Mrigal, Silvercarp, Grasscarp,Common carp
Mizoram	Rohu, Mrigal, Silvercarp, Grasscarp,Commoncarp
Meghalaya	Rohu, Mrigal, Silvercarp,Grasscarp,Commoncarp,Pangasius spp, Trout
Manipur	Rohu, Mrigal, Silvercarp, Grasscarp, Common carp and Labeo gonius, Pengba
Sikkim	Common carp, Grasscarp, Rainbow trout
Tripura	Rohu, Catla, Mrigal, Grass carp,Common carp,Pabda

The State-wise details of fish production in North-Eastern States during last nine years are furnished given below: (in lakh tonnes)

Sl. No	Name of the State	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
1	**Assam**	2.83	2.94	3.07	3.27	3.31	3.73	3.93	4.17	4.43
2	**Arunachal Pradesh**	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.09
3	**Manipur**	0.31	0.32	0.32	0.33	0.32	0.32	0.33	0.33	0.34
4	**Meghalaya**	0.06	0.11	0.12	0.12	0.13	0.14	0.16	0.18	0.19
5	**Mizoram**	0.06	0.07	0.08	0.08	0.07	0.07	0.04	0.05	0.05

6	**Nagaland**	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09
7	**Sikkim**	0	0	0	0	0	0	0	0	0.01
8	**Tripura**	0.65	0.69	0.72	0.77	0.7	0.78	0.82	0.82	0.83
Total		**4.03**	**4.25**	**4.44**	**4.70**	**4.67**	**5.18**	**5.43**	**5.69**	**6.04**

Scenario of Fish Production & Consumption in North East India:

The Inland fish production in North Eastern States recorded an average annual growth rate of 5.38% during last nine years i.e. from 2014-15 to 2022-23. The total fish production in the North Eastern States increased from 4.03 lakh tonnes in 2014-15 to highest production of 6.04 lakh tonnes during FY 2022-23. As per the latest data published by the Handbook of Fishery Statistics, 2020, more than 26.3 lakh people of the region are associated with the sector for livelihood.

Riverine fishery resources of the states of North East region have diversified fish fauna but still the old traditional methods of fishing are being used and primitive and outdated practices are followed for fishing. A large number of diseases occur in fishes, due to nutritional deficiency or unhygienic condition of water or attack of parasites. Among the fish diseases parasites and bacterial diseases are being one of the most concern factors in the North East India.

It is difficult to make fish farming productive and lucrative in already heavily fish deficit NE India following organic practices. Presence of diverse aquatic resources, starting from coldwater to warm water, tropical fish to semi-tropical fish to temperate fish for diversification of aquaculture. Most of the water bodies sustain high productivity throughout the year, in some places of Tripura and Assam, the average fish productivity is more than 3 MT/ha/year even after low-input management, which indicates scopes for further improvement in the production of fish by intensifications. Further NE is a hub for ‘high-value fish’ such as Pabda, Tengra, Pengba, Chital, Mahseer, Scampi, etc. for development of ventures of commercial importance.

Huge demands for fish as more than 95% of people are active fish consumers. Further, there is a competitive market price ranges from Rs. 150 to 500/ kilogram for carps to Rs. 500-1500/- for catfish like Pabda, Tengra, Magur, Singhi, etc. The SIS-Small Indigenous Species

(Mola, Darkina, Puthi, Kanla, etc) which are considered as 'fish of no importance to fisheries in many inland states' have high demand and price in NE India, sometimes, their price is higher than most of our commercially important species of carps.

Pig is considered as a cultural icon for NE India, through pig cum fish farming, huge socio-economic transformation is possible in the region particularly among the adivasi communities. Paddy cum fish farming is the most underestimated resource in NE India; at present, the potential area for paddy-fish farming is more than 27000 ha with an average fish productivity is >250 kg/ha/year. Rice and fish are the two major ingredients in the daily diets of NE people, paddy-fish farming can immensely backstop the nutritional security of the region. Great opportunities for ornamental fish farming; in India's ornamental fish trade, the contribution from NE India is >85%. Some high-value ornamental of international importance from NE India are- *Channa barca, Colisa fasciata., Botia dario, Rasbora daniconius,* etc.

The demand for fish is very high in NE India as more than 95% of populations are active fish consumers. Further the tendency of the people to consume fish more than nutritional requirement (12 kg/capita/annum) is a great challenge for the sector to overcome through technological interventions. Tripura is nutritionally self-sufficient in fish production but in an estimate, it was recorded that the state annually spends about Rs.400 Crores for importing fish from outsides to meet the local demand.

Fish Disease occurance in North East India & remedial procedure

Fish disease has emerged as an important constraint in fisheries and aqua culture in the state. Epizootic Ulcerative Syndrome (EUS) caused by *Aphanomyces invadans* was the most frequently encountered fish disease in the state of Assam. The outbreak of EUS in India reportedly started from the Barak valley of Assam and Tripura in 1988.Saprolegniasis (by *Saprolegnia parasitica*) was less frequent/ lethal fungal disease than EUS. Most commonly encountered bacterial fish diseases of north eastern states were infectious abdominal dropsy (by *A. hydrophila*), followed by fin & tail rot disease (by *Pseudomonas fluorescens* and *A. hydrophila*), ulcer disease (by Aeromonas spp. and Pseudomonas spp.) and eye disease of Catla (by *Aeromonas liquefaciens*). Argulosis (by *Argulus foliaceus*), Lernaeosis (by *Lernaea cyprinacea*), Dactylogyrosis & Gyrodactylosis (by monogenetic trematodes Dactylogyrus and Gyrodactylus sp.), Ichthyophthiriasis (by *Ichthyophthirius multifiliis*) and Trichodiniasis (byciliate protozoan Trichodina sp.) were other parasitic diseases reported from Assam.

Argulosis recorded the second highest incidence rate in aquaculture ponds of the state after EUS in Assam. A few cases of nutritional diseases like pin-head syndrome, lordosis and scoliosis were reported from culture ponds. Environmental diseases like asphyxiation, gas bubble disease and acidosis have also been reported from this north eastern state. Helminth parasites are extensively distributed in the freshwater fishes of different regions of north eastern India and are primarily found in the intestine of the fishes. Females are found to be highly infested than males. Also, the seasonal influence was observed on the occurrence of parasites.

Poor water quality, such as high ammonia or nitrite levels, can stress fish and make them more susceptible to diseases. Fluctuations in water temperature, oxygen levels, and pH are impacting the fish health. Management of fish diseases in North East India involves a combination of preventive measures, such as maintaining good water quality, proper nutrition, and biosecurity practices, as well as early detection and treatment of diseases using appropriate medications or interventions.

Disease outbreak, particularly the outbreak of deadly Epizootic ulcerative syndrome (EUS) during the winter months. Tripura was the gateway for this disease when occurred first in the Indian subcontinents in September, 1988. Even after 35 years from its first occurrence, there is no effective measure against this disease; production penalty varies from 70 to 100%, farmers fear while investing fresh in aquaculture. The States of North East India are marching towards organic farming or organic package of practices; Sikkim and Meghalaya are already declared organic states. In some places, farming is organic by default, but in other places inclination towards organic farming and declaration of organic state poses threats to the production and productivity of fish in the region.

By the help of ethno-botanical remedies, fish disease which is responsible for 20-30% of production penalty could be minimized by 30 to 50%. One important ITK to mention here is the use of concoction of kerosene, mustard oil cake and soil to control the infection of deadly transboundary fish disease Epizootic ulcerative syndrome (EUS) by almost 100% in Tripura. To correct soil acidity, as an alternative of lime, the ash of banana, mustard, paddy straw, fly ash from kilns etc can be used to minimize the cost of applying lime in aquaculture.

Inputs from Govt of India in North East Fisheries:

Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying implemented Blue Revolution, Centrally Sponsored Scheme from 2015-16 to 2019-20 for development of fisheries and aquaculture in the country and the project worth Rs, 391.95 crore were sanctioned for North Eastern States. To consolidates the success and achievements of Blue Revolution, in the year 2020-21, the Government of India launched an another flagship schemes namely Pradhan Mantri Matsya Sampada Yojana (PMMSY) with an investment of Rs.20,050 crore for a period of 5 years with effect from Financial Year 2020-21 to 2024-25 for holistic development of fisheries and aquaculture.PMMSY aims to enhance the fish production through establishment of new freshwater finfish hatcheries, construction of rearing ponds, grow-out ponds with inputs, biofloc ponds, Re-circulatory Aquaculture System (RAS), ornamental fish rearing unit, providing boats and nets for traditional fishermen etc. Minimum 10% of the annual allocation under the scheme has been earmarked for North Eastern Region.

Under PMMSY, total projects with outlay of Rs.1391.62 crore have been approved for NER States during 2020-21 to 2023-24 (till date).Besides, to promote easy access to credit for aqua-culture farmers, fish farms and fishing activities the Government of India in 2018-19 extended the facility of Kisan Credit Card (KCC) to fisher and fish farmers to help them meet their working capital needs. So far, a total of 1, 70, 674 KCC with a loan amount of Rs. 1893.43 crore have been issued including 16,870 KCC in North East Region.

Eventually DCFR has also joined with Meghalaya Govt to sustain the cold water fisheries in North East region.

Conclusion

With its vast water resources and diverse aquatic life, North East India has significant potential to become a leader in fisheries and aquaculture. Strategic investment in infrastructure, research, and sustainable practices can transform the region into a hub of fish production, contributing to food security, economic growth, and environmental conservation.

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MANAGEMENT OF VIRAL PATHOGENS THROUGH NANOTECHNOLOGICAL APPROACHES

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Abstract

Plant viruses account for approximately 47% of the total crop losses resulting from plant diseases, causing substantial losses in agricultural productivity. It has been reported that viruses, which are unavoidable or uncontrollable, are the cause of more than 50% of newly emergent plant illnesses. Therefore, developing new and efficient management techniques is crucial to halting the plant virus's damage to economically significant crops.Despite the growing body of research showing the effectiveness of engineered nanomaterials in treating many plant infections, relatively little is known about their effects on phytoviruses. In this article, we discuss the newly developing discipline of "Nanophytovirology" as a possible management strategy for illnesses caused by plant viruses. Nanoparticles (NPs) have unique physiochemical characteristics that allow them to interact in a number of targeted and beneficial ways with viruses, their vectors, and the host plants.

Introduction

Plant pathogens and pests cause substantialqualitative and quantitative crop losses, significantly confounding efforts to sustain food security. Phytoviruses represent a major threat to plant health, leading to considerable agricultural damage due to their genomic variability, swift evolutionary changes, and the overall lack of effective management strategies. Out of the global food production loss due to plant diseases, viral diseases account for 47% of this loss (Anderson *et al.*, 2004; Popp and Hantos, 2007; Boualem *et al.*, 2016). Due to the low cost of agricultural production practices, nanoparticles have wonderful applications in the fields of high-sensitivity biomolecular detection, disease diagnostics, and antimicrobial and therapeutic compounds. As a result, they are expected to increase agricultural productivity (Dutta, 2012; Dutta *et al.,* 2021). The benefit of using nanoparticles (NPs) in plant pathology is that they are very reactive, have a maximum surface area, and are incredibly small (less than 100 nm) (Jeevanandam*et al.,* 2018).Although the use of nanoparticles as antifungal and antibacterial agent has been broadly studied, but the study of effectiveness of NPs against viral pathogen is still an emerging field for the researchers.

Mechanism of nanoparticles against viral pathogen

As we have mentioned above, the use of NPs against viral pathogens has not been broadly studied and the relevant mechanisms of action by which NPs interact with plant viruses have not been thoroughly described yet.However, certain studies showed the effectiveness of NPs against phytoviruses. Some researchers reported that nanoparticles directly interact with the viral capsid protein, thereby causing structural disruption of virus particles that lead to viruses' aggregation and rapid deactivation. Another study showed that the application of certain nanoparticles induces plant growth even after it is infected by a viral pathogen but is not able to suppress the pathogen. Apart from the direct involvement of NPs with viral pathogen it can be used as an indirect manner to suppress viral pathogen by inducing plant growth and plant defense mechanism. In a study Mitter *et al.* demonstrated that dsRNA can be effectively delivered to plants using nontoxic and degradable layered double hydroxide bioclay nanosheets (BioClay).

Successful examples for management of soil borne pathogens using nanoparticles

In India, Jain (2014) proved AgNPs to be an effective antiviral agent and showed complete suppression of *Sunhemp rosette virus* (SHRV) disease on cluster bean after spraying an aqueous solution of AgNPs @50 ppm. Hao *et al.* studied the use of Fe_20_3NPs treatment against turnip mosaic virus (TuMV) which directly interact with viral capsid proteins, resulting in structural disruption causing aggregation and rapid deactivation of viral particles. El-Dougdoug*et al.* studied the effectiveness of AgNPs foliar spray at 50 mg/L on greenhouse-grown tomato plants which reduced ToMV-induced local lesions. Importantly, the authors also reported that antioxidant enzymes (PPO and POD) and total soluble protein contents were elevated with treatment.

Conclusion

A possible method for long-term crop virus protection is nanophytovirology. Most of the work done to clarify NPs' direct antiviral function has been limited to in vitro investigations. Furthermore, the production of crops worldwide is constantly threatened by DNA plant viruses, despite the fact that they are not as common or well-researched as RNA phytoviruses. For instance, a significant and quickly developing class of circular, single-stranded DNA plant viruses is represented by geminiviruses. They can result in catastrophic crop losses and have a wide host range that includes both wild and domesticated plants.As management tactics, composites of NPs with other nutrients, pest management techniques, or biostimulants ought to be looked into. It is also important to investigate the likelihood of using NP-mediated plant virus and vector management as part of integrated disease control. Biologists, agricultural engineers, plant pathologists, and other experts from different fields must work together to create nanophytovirology in a healthy way. Therefore, the creation of a long-lasting, safe, effective, sustainable, and environmentally friendly management strategy against plant viral infections must be the main focus of efforts.

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TECHNOLOGICAL INNOVATIONS IN AGRICULTURE

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Abstract

Precision farming, biotechnology, automation, and other technological advancements in agriculture are revolutionizing the sector by raising sustainability and production. Precision farming maximizes yields while reducing waste by utilizing GPS and data analytics to optimize resource utilization. In order to increase food security, biotechnology provides solutions like genetically engineered crops that are resistant to illnesses and pests. Labour-intensive jobs are streamlined by automation and robotics, which boost productivity and cut expenses. These developments encourage ecologically friendly activities in addition to helping farms adjust to climate change. In the end, these technologies are essential for meeting the world's food needs and maintaining agricultural resilience.

Keywords: Precision farming, Innovations, Biotechnology, GIS, GPS, Smart farming

Introduction

Agriculture is the backbone of many economies worldwide, providing food, raw materials, and employment. With a global population projected to reach nearly 10 billion by 2050, the demand for food is set to increase significantly. Traditional agricultural practices face numerous challenges, including climate change, resource depletion, and urbanization. In response, the agricultural sector is undergoing a technological transformation. Technological transformation refers to the profound changes that occur in processes, systems, and practices as a result of adopting and integrating new technologies. This transformation can impact various aspects of society, including industries, economies, and daily life. Under innovation Adoption the new technologies are introduced that improve efficiency, productivity, or quality. Process Reengineering redesign workflows and processes to leverage new technologies, leading to enhanced performance. Changes in organizational culture and mindsets as individuals and groups adapt to new tools and methodologies. Overall, technological transformation is a dynamic process that reshapes how industries operate and how individuals interact with technology and each other. This article explores the most impactful technological innovations in agriculture.

1. PRECISION AGRICULTURE

Precision agriculture refers to the use of technology to monitor and manage field variability in crops. It integrates information technology with agricultural science to optimize field-level management regarding crop farming. Technologies Involved in Precision Agriculture are:

Global Positioning Systems (GPS): Allow farmers to map fields accurately and track their vehicles in real-time.

Geographic Information Systems (GIS): Help in analyzing soil types, moisture levels, and crop health.

Remote Sensing: Involves the use of satellite or drone imagery to assess crop health and soil conditions. Precision agriculture, also known as precision farming, involves using technology and data analysis to optimize farming practices and enhance productivity. Here are some of the important benefits of precision agriculture:

a) Increased Crop Yields

Precision agriculture allows farmers to apply fertilizers, pesticides, and water only where needed, which can lead to healthier plants and higher yields. Utilizing data analytics helps in making informed decisions regarding crop management, leading to improved productivity.

b) Resource Efficiency

Precision irrigation techniques help optimize water use, reducing waste and conserving this vital resource. By applying inputs more efficiently, farmers can lower costs associated with fertilizers, pesticides, and water.

c) Environmental Sustainability

Precision agriculture minimizes the application of chemicals, which can help decrease pollution and protect ecosystems. Improved practices can lead to healthier soil and ecosystems, supporting a greater diversity of plants and wildlife.

d) Enhanced Soil Health

Technologies like soil sensors allow farmers to monitor soil health and conditions, leading to better management practices. Precision farming enables farmers to provide nutrients based on specific soil needs, improving soil structure and fertility over time.

e) Improved Farm Management

Precision agriculture integrates various data sources (like satellite imagery, weather data, and soil sensors) for comprehensive farm management. Continuous monitoring of crops and soil conditions allows for timely interventions, reducing the risk of crop failures.

f) Economic Benefits

Increased efficiency and yields can lead to higher profitability for farmers. Utilizing cutting-edge technology can enhance a farmer's competitive edge in the market.

g) Risk Management

Advanced data analysis can help forecast crop performance and potential risks, allowing farmers to take proactive measures. Better monitoring and management strategies can improve resilience against climate change impacts and pest invasions.

h) Labour Efficiency

Precision agriculture often incorporates automated systems, reducing labor costs and improving operational efficiency. Data analytics can help streamline tasks, ensuring that labour is used effectively.

i) Customization and Flexibility

Farmers can tailor their practices based on specific field conditions, crop varieties, and market demands. Precision farming technologies can be scaled up or down based on the size of the farm and specific goals.

j) Traceability and Transparency

Improved data collection allows for better traceability of food products, which can enhance consumer trust and meet regulatory requirements. Increased transparency can help farmers share information about sustainable practices with consumers, improving brand reputation.

While precision agriculture offers many benefits, it also presents several challenges that farmers and stakeholders must navigate. Here are some of the main challenges:

i. **High Initial Costs**

The upfront costs for equipment, software, and training can be significant, making it a barrier for smaller farms. Regular updates and maintenance of technology can also incur additional expenses.

ii. **Complexity of Technology**

Farmers may require training to effectively use advanced technologies and interpret data, which can be discouraging for some. Different systems and technologies may not work effortlessly together, complicating the farming process.

iii. **Data Management and Analysis**

The large amount of data generated can be overwhelming, and farmers may struggle to analyze and utilize it effectively. Sharing data with third-party providers raises concerns about privacy and ownership.

iv. **Access to Reliable Internet and Technology**

In rural areas, limited internet access can hinder the use of cloud-based applications and real-time data sharing. Not all farmers have access to the latest technology, leading to disparities in adoption.

v. **Adapting to Climate Variability**

Changes in climate can affect the reliability of predictive models and data-based decisions. Different areas within a single farm may have unique soil characteristics, complicating the application of uniform practices.

vi. **Regulatory Challenges**

Navigating agricultural regulations and ensuring compliance can be complex, especially with new technologies. Farmers may face challenges related to data ownership and sharing, especially concerning privacy laws.

vii. **Cultural Resistance**

Some farmers may be hesitant to adopt new technologies due to a preference for traditional farming methods. Shifting to precision practices often requires a cultural change within farming communities.

viii. **Economic Risks**

Economic uncertainties can make it difficult for farmers to justify the investment in precision technologies. Over-reliance on technology can lead to vulnerabilities if systems fail.

ix. **Skill Gaps**

There may be a lack of skilled workers who can operate advanced technologies and analyze data effectively. Limited access to educational resources can hinder knowledge transfer and training.

x. **Environmental Impact Concerns**

If not managed properly, precision agriculture can still lead to overuse of fertilizers and pesticides in some cases. The long-term sustainability of high-tech practices must be considered to avoid negative environmental impacts.

2. BIOTECHNOLOGY

In order to apply organisms and parts of them for goods and services, biotechnology is a multidisciplinary field that integrates the natural sciences and technical sciences. Techniques such as CRISPR and gene editing allow for precise modifications of plant genomes to improve traits like drought resistance and pest resistance. Beneficial microbes can enhance soil fertility and crop health. Crops can be engineered to withstand environmental stresses, such as droughts and floods. GMOs can reduce the need for chemical pesticides and fertilizers, lowering production costs and environmental impact. Biotechnology offers significant potential in various fields, including agriculture, medicine, and environmental science. However, it also faces several challenges that can impede its development and adoption. Here are some important challenges associated with biotechnology:

a) **Regulatory Hurdles**

Navigating the regulatory landscape can be lengthy and complex, often delaying the introduction of new biotechnological products. Different countries have varying regulations, which can complicate international research and commercialization efforts.

b) **Public Perception and Acceptance**

Many people have concerns about genetically modified organisms (GMOs) and biotechnology in general, often due to misinformation or lack of understanding. Issues surrounding genetic modification, cloning, and potential impacts on biodiversity raise ethical questions that can influence public acceptance.

c) **Economic Barriers**

Developing biotechnological products requires substantial investment, which can be a barrier, especially for small companies. Established agricultural practices and products may resist competition from biotechnological innovations, impacting market viability.

d) Intellectual Property Issues

Navigating intellectual property rights can be complex, leading to disputes over ownership and licensing. Patent restrictions can limit access to critical biotechnological advancements, particularly for small farmers or developing countries.

e) Technical Challenges

Understanding and manipulating biological systems can be intricate, with unpredictable results. Transitioning from lab-scale to commercial production often presents technical difficulties that need to be overcome.

f) Environmental Concerns

The introduction of genetically modified organisms can potentially affect local ecosystems and biodiversity. Overuse of biotechnological solutions, such as pest-resistant crops, can lead to the development of resistant pests or pathogens.

g) Ethical and Social Issues

There are concerns about access to biotechnological advancements, particularly for marginalized communities. Issues of control over agricultural resources and the impact of biotechnology on traditional farming practices can raise social justice concerns.

h) Lack of Education and Awareness

Limited understanding of biotechnology among consumers, policymakers, and even some farmers can hinder informed decision-making. There is a need for training programs to help stakeholders understand and implement biotechnological innovations effectively.

i) Health and Safety Concerns

The long-term health effects of consuming biotechnologically modified products are still a subject of research and debate. Concerns about potential allergic reactions or toxic effects from genetically modified foods persist in public discourse.

j) Global Disparities

Developing countries may struggle to access biotechnological tools and expertise, widening the gap in agricultural productivity. Limited resources in some regions can hinder research, development, and application of biotechnology.

3. SMART FARMING

Smart farming incorporates advanced technologies to improve the efficiency and productivity of agricultural operations. Sensors and devices collect data on soil moisture, weather conditions, and crop health, enabling real-time decision-making. Artificial Intelligence (AI) algorithms analyze data to provide insights and predictive analytics for better farm management. Robotics and Automated machinery can perform tasks such as planting, weeding, and harvesting. Automation reduces the need for manual labour, which is particularly valuable in regions facing labour shortages. Access to real-time data helps farmers make informed decisions, optimizing resource use and increasing yields. The cost of smart farming technologies can be a barrier for small and medium-sized farms. The increased use of connected devices raises concerns about data privacy and cyber security.

4. SUSTAINABLE AGRICULTURE TECHNOLOGIES

Sustainable agriculture technologies focus on practices that meet current food needs without compromising the ability of future generations to meet their own. Combining ecological principles with agricultural practices to create resilient farming systems. Innovations in organic farming, such as bio pesticides and organic fertilizers, promote sustainability. Growing crops in stacked layers using controlled-environment agriculture (CEA) to maximize space and resource efficiency. Sustainable practices minimize the use of harmful chemicals and preserve biodiversity. Technologies such as rainwater harvesting and drip irrigation conserve water and improve soil health. Sustainable products may face challenges in reaching broader markets due to consumer preferences. Farmers need access to training to implement sustainable practices effectively.

5. DIGITAL AGRICULTURE

Digital agriculture leverages digital tools and platforms to enhance agricultural practices, from farm management to supply chain logistics. Platforms that help farmers track inputs, monitor crop progress, and manage finances. Blockchain Technology enhances traceability in the supply chain, ensuring food safety and reducing fraud. E-commerce Platforms connect farmers directly with consumers, increasing market access. Blockchain provides a transparent record of food origins, fostering consumer trust. E-commerce allows farmers to reach a broader customer base, enhancing profitability. Access to digital tools can be limited in rural areas, creating disparities among farmers. Farmers may require training to effectively utilize digital tools.

6. CLIMATE-SMART AGRICULTURE

Climate-smart agriculture (CSA) refers to practices that increase productivity while enhancing resilience to climate change and reducing greenhouse gas emissions. Integrating trees into farming systems to improve biodiversity and carbon sequestration. Practices such as no-till farming that improve soil health and reduce erosion. CSA practices help farmers adapt to changing climatic conditions. Agricultural practices can contribute to mitigating climate change by sequestering carbon in soils and biomass. Farmers may lack access to the resources and knowledge needed to implement CSA practices. Effective policies are necessary to support the adoption of climate-smart practices.

Conclusion

Technological innovations in agriculture have the potential to transform the sector, addressing the pressing challenges of food security, environmental sustainability, and economic viability. As these technologies continue to evolve and become more accessible, their integration into farming practices will be critical for building a resilient agricultural future. The successful implementation of these innovations will require collaboration among farmers, policymakers, researchers, and technology developers to ensure that the benefits are widespread and inclusive. As we look to the future, the agricultural sector must embrace innovation while remaining committed to sustainability and equity, ensuring that all stakeholders can thrive in a rapidly changing world.

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ENHANCING RICE RESILIENCE: GENE PYRAMIDING FOR ABIOTIC STRESS TOLERANCE

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Abstract

Rice is a vital food source for over half the global population but faces cultivation challenges due to environmental stresses like water scarcity, salinity, flooding, and extreme heat. These conditions adversely affect rice growth, productivity, and grain quality, posing a threat to global food security amid climate change. Gene pyramiding, which integrates multiple stress-resistant genes into a single rice variety, offers a promising solution. Combining conventional breeding with advanced biotechnological techniques such as marker-assisted selection (MAS), this method enhances rice resilience to multiple stressors, boosts adaptability to environmental changes, and supports sustainable farming. Ultimately, gene pyramiding is crucial for safeguarding rice production and ensuring food security in an unpredictable climate.

Key words: Rice, Abiotic stress, Gene pyramiding

Introduction

Rice is a staple food for many global populations, especially in Asia. Rice, a water-loving crop is usually grown under continuous land stagnation. Rice comes in various types, with white rice being the most prevalent and brown rice offering greater nutritional benefits due to the due to its intact outer layers. Aromatic varieties such as jasmine and basmati are also popular across the world. It is an excellent source of nutrients such as protein, thiamine, riboflavin, niacin, phosphorous,iron, potassium, and gluten free carbohydrates. It can be boiled, fried, or added to soups and salads. Beyond nutrition, rice symbolizes abundance and heritage in many cultures, making it vital in global diets. However, rice cultivation is severely affected by various abiotic stress and environmental factors that hinder plant growth and yield.Abiotic stresses have evolved as a major threat to global food security.

Impacts of abiotic stresses on rice productivity

Rice production is significantly challenged by abiotic stresses,including, drought, salinity, submergence, and high temperatures. These abiotic factors have varying impact on rice crop productivity and contributes to severe yield losses.

Drought Stress

Drought-induced water scarcity hinders nutrient uptake, causing stunted growth, reduced crop yields, and lower grain quality. Symptoms include wilting leaves, fewer tillers, and premature aging. Crop losses can vary between 30% and 70%, depending on the drought's duration and severity, especially during key developmental stages like flowering. Limited water availability critically affects nutrient absorption, leading to these detrimental effects on growth and yield.

Salinity

High salt concentrations in water and soil severely affect plant’s nutrient absorption, leading to toxic ion buildup and osmotic pressure problems. Salinity results in leaf yellowing, stunted growth, and reduced grain production. Crop yields can decline by 20% to 50%, with higher salinity causing greater reductions, particularly in salt-sensitive plants.

Submergence

Some rice varieties thrive in flooded conditions, but excessive flooding depletes root oxygen, causing root rot and reduced photosynthesis. Symptoms include yellowing leaves, stunted growth, and heightened disease susceptibility. Prolonged flooding can lead to yield losses of 20% to 100%, contingent on submergence duration and the plant's growth stage at the time of flooding.

High Temperatures

High and low temperatures can adversely affect various growth stages, from germination to grain filling, resulting in poor seed set, reduced biomass, and yield losses ranging from 10% to 50%, especially during flowering and grain filling phases.

Development of Climate-Smart Rice

Understanding and addressing environmental pressures is vital for sustainable rice production. Many common rice varieties are vulnerable to these stressors, widening the gap between potential and actual yields in adverse conditions. Traditional genetic enhancement methods for improving rice's abiotic stress tolerance have been limited due to complex mechanisms and assessment challenges. Advances in molecular genetics and genotyping have pinpointed key quantitative trait loci (QTLs) linked to stresses like drought, flooding, and salinity. Applying these QTLs via molecular breeding has led to stress-resistant versions of popular rice varieties. However, there has been limited research on developing rice genotypes resistant to multiple abiotic stresses by combining QTLs for drought, salinity, and submergence tolerance using marker-assisted selection (MAS). This review comprehensively covers the development of rice varieties tolerant to multiple abiotic stresses such as drought, submergence, salinity, and high temperature through gene stacking.

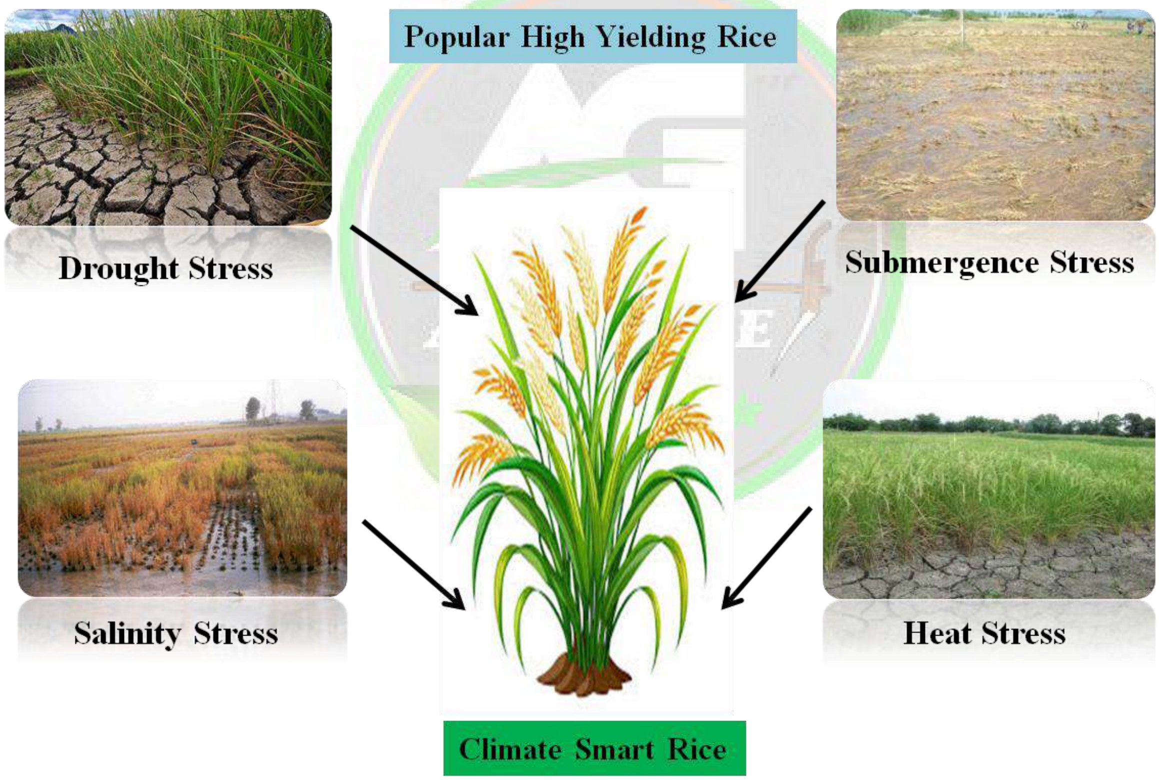

Figure: Resilient Rice: Thriving in Changing Climates

Climate-smart rice offers several benefits, including enhanced crop stability,crop productivity, and promotes eco-friendly farming with minimal water usage and low chemical applications. Itguarantees a consistent rice food supply, which is crucial for feeding a significant portion of the global population.

Conventional Breeding

Traditional breeding, also known as conventional breeding, is a process that involves choosing parent plants with sought-after traits and intentionally crossing them to create offspring with enhanced characteristics.

Process of Conventional Breeding

1. Parent Plant Identification: Choose parent plants exhibiting desired phenotypic characteristics, such as high yield, resistance to diseases, or ability to withstand drought.
2. Hybridization: Perform controlled pollination between selected parents to generate hybrid seeds, ensuring the intended parentage.
3. Offspring Assessment: Cultivate the resulting progeny and assess them for the targeted traits. This process often requires multiple generations to establish stable desired characteristics.
4. Plant Selection: In each generation, identify and choose the top-performing plants for continued breeding. This phase can span many years, as traits must be expressed and stabilized.
5. Environmental Testing: Implement comprehensive trials across various environments to evaluate the new variety's performance.
6. Release: After rigorous testing, a new variety can be released to farmers.

Advantages

- Genetic Diversity: Preserves a diverse genetic foundation, which is crucial for species' long-term adaptability and resilience.
- Simplicity: Doesn't necessitate sophisticated technology or tools, making it readily available to various breeders, particularly in less developed areas.

Limitations

- Time-Consuming: The process can take many years, often decades, to develop a stable variety with multiple desirable traits.
- Limited Trait Combinations: Traditional breeding may struggle to combine several traits simultaneously compared to gene pyramiding.

Gene Pyramiding

Gene pyramiding is the process of combining multiple genes that confer tolerance to different stressors into a single plant variety. This technique aims to enhance overall plant resilience and adaptability by integrating multiple advantageous traits, such as drought tolerance, salinity tolerance, submergence tolerance and heat resistance.

Process of Gene Pyramiding

1. Trait Identification: Identify specific genes associated with desirable traits through genetic studies and research. For rice, these traits could include drought tolerance, pest resistance, and higher yield.
2. Parent Selection: Choose parent lines that possess the desired traits. These can be either traditional varieties or genetically modified organisms (GMOs).
3. Crossing: Cross the selected parent lines to combine the desired genes. This can be done through traditional breeding methods or advanced techniques like marker-assisted selection (MAS).
4. Backcrossing: In some cases, backcrossing with one of the parent lines may be done to ensure that the new variety retains other essential traits (e.g., grain quality).
5. Selection: Use molecular markers to select progeny that carry the desired combinations of genes. This step accelerates the identification of plants with the desired traits.
6. Field Trials: Test the selected lines in various environmental conditions to assess performance, stability, and adaptability.
7. Release: Once a suitable variety is developed, it is evaluated and released for cultivation.

Advantages

- Multiple Trait Integration: Can combine several beneficial traits into one variety, enhancing overall resilience.
- Increased Stability: Improved ability to withstand adverse conditions, leading to stable yields.
- Efficiency: Modern techniques like MAS and CRISPR allow for faster and more precise breeding compared to traditional methods.

Applications

- Development of climate-smart rice varieties that can thrive in varying environmental conditions.
- Resistance to multiple diseases or pests, reducing the need for chemical inputs.

Conclusion

Gene pyramiding and conventional breeding have their own merits and challenges.Conventional breeding remains a fundamental method that leverages natural genetic diversity and traditional selection practices.On the other hand, Gene pyramiding for climate-smart rice is a promising strategy to combat the challenges posed by climate change. By integrating multiple beneficial traits, this approach can lead to more resilient rice varieties, contributing to global food security and sustainable agricultural practices.

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ANEMIA IN SHEEP AND GOATS

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Introduction

Sheep rearing is a traditional occupation and contribute greatly to the agrarian economy, especially in areas where crop and dairy farming are not economical, and play an important role in livelihood of a large proportion of landless, small and marginal farmers. Anemia is a condition which silently kills the production capabilities and reproductive traits and suppresses the resistance power of animals (Anumol *et al*, 2011). Clinically, anemia is characterized by pale mucus membranes, decrease in the packed cell volume (PCV), hemoglobin concentration (Hb), and total erythrocyte count (TLC) per unit volume of blood with values below the normal generally observed in hydrated animals (Neha *et al*, 2022). Anemia can be due to various reasons like endoparasitism, ectoparasitism, hemoparasitism, nutritional deficiencies and secondary to certain infectious diseases.

Incidence of anemia

The young ones of the sheep and goat have highest incidence of anemia than the adults. This could be due to immune suppression in young animals making them prone to ectoparasites and endoparasites, dietary deficiency and secondary infections. Incidence of anemia in sheep was higher in females than males. In anemic small ruminants, reduction in Hb, PCV, RBC count were prominent. There may be marked elevation of neutrophils and monocytes in anemic sheep and goat with mixed and other infections. The decreased hematological indices (Hb, PCV, and TEC) could be attributed to the reduced appetite, blood loss from scratching, and inflammatory response due to these infections. It has been found that lice infestation causes an increase in oxidative markers of blood and erythrocytes being very prone to oxidative damage can result in significant Anemia in infected animals (Ajith *et al*, 2017).

Parasitic infection

Parasitic infection which is ruled out by fecal examination of parasitic eggs of *Strongyles Spp., Trichuris Spp., Fasciola Spp., and Strongyloides Spp., along with certain protozoa like Balantidium Spp., and Eimeria Spp.,* and certain hemoprotozoan diseases l*ike Theileria sp., Anaplasma sp., Trypanosoma sp., Babesia sp.* which is confirmed by examination of peripheral blood smear causes anemia.

The various etiologies included in sheep were ectoparasitic infestation, endoparasitic infection, mixed infection and other conditions like nutritional deficiency, blood loss due to accidents and/or trauma.

Pale conjunctival and buccal mucus membrane in a sheep

Ectoparasitism

Ectoparasitism was the major cause for anaemia in small ruminants that leads to major economic loss due to poor management practices. Climatic condition conducive to the growth and multiplication of ectoparasites, poor management, poor awareness among farmers and poor animal health services contributed to the widespread occurrence of ectoparasites (Sertse and Wossene, 2007). Increased incidence of endoparasites in small ruminants could be due to poor management systems i.e., animals repeatedly grazing on infested pastures, animals allowed to graze on nearby ponds/water sources, overcrowding in unhygienic pen, immunosuppression due to nutritional/mineral deficiency and transport stress predispose the animals to high parasitic infections.

However, in case of other infections like bacterial (Pneumonia, Enteritis), viral (PPR, Contagious Ecthyma) and nutritional deficiencies, anemia was observed as secondary clinical sign leading to delayed recovery, generalized weakness and poor weight gain. Anaemia in these infections may attribute to the negative influences of the pathological and clinical features of the disease (i.e., diarrhea, malabsorption, etc.), which distort protein synthesis in the liver and also the production of erythrocytes in the bone marrow and chronic inappetance leading to malnutrition.

Conclusion

Anemia in small ruminants is multifactorial which includes ectoparasites, endoparasites, mixed and other infections which leads to clinically generalised weakness, pale mucus membranes, poor weight gain, immunosuppression, secondary bacterial infections and mortality in extreme cases.

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LUMPY DISEASE AND ITS MANAGEMENT

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Introduction

Lumpy disease was mainly found in Africa from 1929 to 1978. Later, this disease gradually entered neighboring countries as well. After 2013, this disease is spreading rapidly. Now this disease has spread to many European and Asian countries. In India, this disease was first reported in the state of Odisha in August 2019. After that, this disease was found in the states of Jharkhand, West Bengal, Chhattisgarh, Telangana, Andhra Pradesh, Karnataka and Kerala. In Maharashtra, the spread of this disease has been detected from Sironcha in Gadchiroli district since March 2020. A definite diagnosis of the epidemic here has been made at the National Diagnostic Laboratory located at Gopal.

Symptoms of Lumpy Disease

First of all, water comes from the eyes and nose of the animals. Swollen lymph glands. Initially, fever occurs, milk production decreases, feeding and drinking of water decreases.

Gradually, tumors of ten-fifteen mm diameter appear mainly on the skin of the head, neck, forehead, chest, etc. Due to ulcers in the mouth, it becomes difficult for sick animals to eat feed. Ulcers in the eyes cause wounds and vision becomes impaired. Some animals walk limping due to swelling in the legs. Lumpy skin disease is a viral skin disease that affects only cattle. It is spread by insects. This disease does not spread from animals to humans.

Preventive measures

Since Lumpy is an infectious disease, cattle keepers should take necessary precautions to prevent the spread of the disease. Proper cleanliness of the cowsheds should be maintained to control external pests. Healthy animals should be kept separate from infected animals. Cows and buffaloes should not be kept together. Since this disease is highly infectious in animals, if symptoms like lumps are seen, the nearest veterinary institute head should be contacted immediately. In the affected villages, separate arrangements should be made for drinking water as well as for grazing the affected animals. The third person should avoid going to the cowshed.

The affected area should be cleaned and a sterilizing solution should be sprayed. For this, 1% formalin or 2-3% sodium hypochlorite, phenol 24 can be used. In case of death of animals suffering from this disease, the carcass should be buried in a pit at least 8 feet deep by scientific method and lime powder should be sprinkled below and above the dead animal. Lumpy disease is spread by ectoparasites (mosquitoes, flies, mites, etc.) so all healthy animals as well as the herd should be sprayed with ectoparasites. Vaccination is necessary for disease control and all cows and buffaloes above 4 months of age in the affected villages and within 5 km radius of the affected villages should be vaccinated with the advice of the nearest veterinarian. The affected animals should be treated.

What do animal husbandry experts say?

Livestock farmers should not panic and should keep proper control of insects and flies in the barn and animals should always be kept in a clean, ventilated and dry environment. A plan should be made to spray insecticides in animal sheds every eight days. For this, smoke of neem leaves should be done in the trough in the evening or at night. If tumors of ten to fifteen millimeters diameter appear on the animal's body, contact the veterinarian immediately and take further drug treatment. Proper balanced diet should be maintained during the outbreak of lumpy disease.

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ARTIFICIAL INTELLIGENCE IN CROP IMPROVEMENT: A TECHNICAL OVERVIEW

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Abstract

Artificial Intelligence (AI) is increasingly integral to modern agriculture, particularly in the domain of crop improvement. By harnessing advanced algorithms, machine learning, and data analytics, AI enhances traditional breeding methods, optimizes crop management, and accelerates the development of high-yielding, resilient crop varieties. This article provides a comprehensive technical overview of AI applications in crop improvement, detailing the underlying technologies, key applications, benefits, challenges, and future prospects. Emphasizing the integration of genomic data, phenotypic analysis, pest and disease management, and precision agriculture, the discussion highlights how AI-driven innovations contribute to sustainable and efficient agricultural practices. The article also addresses the barriers to widespread AI adoption in agriculture and explores potential solutions to overcome these challenges, thereby underscoring AI's pivotal role in ensuring global food security and agricultural sustainability.

1. Introduction

The global population is projected to exceed nine billion by 2050, intensifying the demand for food production. Concurrently, agricultural systems face challenges such as climate change, soil degradation, water scarcity, and increasing pest and disease pressures. To meet these demands sustainably, innovative approaches in crop improvement are essential. Artificial Intelligence (AI), encompassing machine learning, deep learning, computer vision, and robotics, has emerged as a transformative force in agriculture. AI's ability to analyze vast datasets, identify patterns, and make predictive models positions it as a key enabler in developing high-yielding, resilient crop varieties.

This article delves into the technical aspects of AI in crop improvement, exploring how AI technologies are integrated into various stages of the breeding and cultivation processes. It examines the applications, benefits, challenges, and future directions of AI-driven crop improvement, providing a detailed understanding for researchers, agronomists, and technology developers.

2. AI Technologies in Crop Improvement

AI encompasses a range of technologies that contribute to crop improvement through data-driven insights and automation. Key AI technologies utilized in this domain include:

2.1 Machine Learning and Deep Learning

Machine Learning (ML) involves algorithms that enable systems to learn from data and improve over time without explicit programming. Deep Learning (DL), a subset of ML, employs neural networks with multiple layers to model complex patterns in large datasets. In crop improvement, ML and DL are used for predictive modeling, genomic selection, phenotypic trait analysis, and decision-making processes.

2.2 Computer Vision

Computer Vision (CV) utilizes image processing and pattern recognition to interpret visual data. In agriculture, CV is applied in high-throughput phenotyping, pest and disease detection, and monitoring plant health through drone and satellite imagery.

2.3 Genomic Data Analysis

AI-driven genomic data analysis involves processing large-scale genetic information to identify genes associated with desirable traits. Techniques such as Genome-Wide Association Studies (GWAS) and genomic prediction models leverage AI to enhance the efficiency of breeding programs.

2.4 Robotics and Autonomous Systems

Robotic systems, equipped with AI, perform tasks such as planting, weeding, and harvesting with high precision. Autonomous tractors, drones, and robotic harvesters contribute to increased operational efficiency and reduced labor costs.

3. Applications of AI in Crop Improvement

AI's integration into crop improvement spans various applications, each leveraging specific AI technologies to enhance agricultural productivity and sustainability.

3.1 Genomic Selection and Breeding

3.1.1 Genomic Data Analysis

AI algorithms process extensive genomic datasets to identify loci linked to traits like disease resistance, drought tolerance, and yield. Machine learning models predict the performance of different genetic combinations, enabling breeders to select superior candidates efficiently. Techniques such as Support Vector Machines (SVM), Random Forests, and Neural Networks are commonly employed in genomic prediction.

3.1.2 Predictive Breeding

By integrating genomic data with phenotypic information, AI can predict how specific genetic traits will express under various environmental conditions. This predictive capability accelerates breeding cycles by reducing the need for extensive field trials, thereby shortening the time required to develop new crop varieties.

3.2 High-Throughput Phenotyping

3.2.1 Imaging Technologies

AI-powered imaging technologies, including drones, satellites, and ground-based sensors, capture high-resolution images of crops. These images are analyzed using computer vision algorithms to assess plant health, growth rates, and stress responses. High-throughput phenotyping enables the rapid evaluation of large populations, facilitating the identification of superior genotypes.

3.2.2 Trait Measurement

Automated systems quantify complex traits such as leaf area, biomass, root architecture, and flowering time. Accurate and consistent measurement of these traits is critical for selecting high-performing varieties and understanding genotype-phenotype relationships.

3.3 Pest and Disease Detection

3.3.1 Early Detection

Machine learning models analyze data from various sources, including images, weather patterns, and soil conditions, to detect early signs of pest infestations and diseases. Early detection allows for timely interventions, reducing crop losses and minimizing the reliance on chemical treatments.

3.3.2 Precision Treatment

AI-driven systems recommend targeted treatment plans based on the specific type and severity of pest or disease. Precision treatment enhances the effectiveness of control measures while mitigating environmental impacts by reducing the unnecessary use of pesticides and fungicides.

3.4 Yield Prediction and Optimization

3.4.1 Predictive Modeling

AI models utilize historical yield data, real-time sensor data, and environmental variables to forecast crop yields accurately. These predictions assist farmers in making informed decisions regarding resource allocation, harvesting schedules, and market strategies.

3.4.2 Optimization Strategies

AI optimizes factors influencing yield, such as irrigation, fertilization, planting density, and crop rotation. By simulating different scenarios, AI identifies optimal management practices that maximize productivity while conserving resources.

3.5 Precision Agriculture Practices

3.5.1 Variable Rate Technology (VRT)

AI analyzes spatial data to determine the precise amount of inputs (seeds, fertilizers, pesticides) required in different areas of a field. Variable Rate Technology (VRT) ensures that crops receive optimal inputs, enhancing resource use efficiency and reducing waste.

3.5.2 Autonomous Machinery

AI-powered autonomous tractors, drones, and robots perform agricultural tasks with high precision and minimal human intervention. These machines improve operational efficiency, reduce labor costs, and enable large-scale data collection for continuous improvement of farming practices.

4. Data Integration and Management

Effective data integration and management are fundamental to leveraging AI in crop improvement. AI systems synthesize data from diverse sources, including genomic databases, phenotypic measurements, remote sensing, weather forecasts, and IoT sensors.

4.1 Multi-Source Data Integration

AI integrates data from genomic sequences, field observations, environmental conditions, and management practices to provide a holistic view of crop performance. This integration facilitates comprehensive analysis and enables the identification of complex interactions between genetic and environmental factors.

4.2 Data Preprocessing and Cleaning

Ensuring data quality is crucial for accurate AI modeling. Data preprocessing techniques, such as normalization, imputation of missing values, and noise reduction, are employed to enhance the reliability of input data. Consistent data formatting and standardization further support effective data integration.

4.3 Data Storage and Access

Scalable data storage solutions, such as cloud-based platforms and distributed databases, are essential for handling the large volumes of data generated in crop improvement studies. Efficient data access mechanisms enable seamless retrieval and analysis, supporting real-time decision-making.

4.4 Decision Support Systems

AI-driven decision support systems (DSS) synthesize integrated data to provide actionable insights and recommendations. These systems assist farmers and breeders in making informed decisions related to breeding strategies, crop management, and resource allocation, thereby enhancing overall agricultural productivity.

5. Benefits of AI in Crop Improvement

The integration of AI into crop improvement processes offers numerous benefits, contributing to increased agricultural productivity and sustainability.

5.1 Increased Efficiency

AI accelerates breeding cycles by enabling rapid genomic selection and predictive breeding. High-throughput phenotyping and automated trait measurement reduce the time and labor required for crop evaluation, enhancing overall efficiency in breeding programs.

5.2 Enhanced Accuracy

AI-driven models improve the precision of trait selection and disease detection. Machine learning algorithms can identify subtle patterns in complex datasets, leading to more accurate predictions and selections of superior crop varieties.

5.3 Cost-Effectiveness

Optimizing resource use through AI reduces costs associated with inputs such as seeds, fertilizers, and pesticides. Precision agriculture practices minimize waste and enhance the cost-effectiveness of farming operations.

5.4 Sustainability

AI promotes environmentally friendly farming practices by optimizing input use, reducing chemical applications, and enhancing resource conservation. The development of resilient crop varieties through AI-driven breeding contributes to sustainable agriculture in the face of climate change.

5.5 Scalability

AI systems can handle large-scale data analysis and management, supporting global agricultural needs. The scalability of AI solutions facilitates their application across diverse agricultural contexts, from smallholder farms to large-scale commercial operations.

6. Challenges and Limitations

Despite the significant potential, the adoption of AI in crop improvement faces several challenges and limitations.

6.1 Data Quality and Availability

High-quality, comprehensive datasets are essential for training effective AI models. Inconsistent data collection methods, missing data, and limited access to large genomic datasets can hinder the performance of AI systems. Ensuring data accessibility and standardization remains a critical challenge.

6.2 Technical Expertise

Implementing AI solutions requires specialized knowledge in data science, genomics, and agricultural sciences. A shortage of technical expertise in certain regions can impede the widespread adoption of AI technologies in agriculture.

6.3 Cost Barriers

The initial investment required for AI technologies, including hardware, software, and training, can be prohibitive, especially for smallholder farmers. Developing cost-effective solutions and financing mechanisms is necessary to promote inclusivity and equitable access to AI-driven innovations.

6.4 Ethical and Privacy Concerns

The extensive collection and analysis of agricultural data raise ethical and privacy concerns. Ensuring data privacy, addressing data ownership issues, and establishing ethical guidelines for AI use in agriculture are essential to maintain trust and protect stakeholders.

6.5 Integration with Existing Systems

Integrating AI technologies with existing agricultural practices and infrastructure can be complex. Compatibility issues, lack of interoperability, and resistance to change may pose barriers to seamless integration.

6.6 Dependence on Technology

Over-reliance on AI and automated systems may lead to vulnerabilities, such as system failures or cybersecurity threats. Ensuring the robustness and security of AI systems is crucial to mitigate potential risks.

7. Case Studies and Examples

Examining real-world applications of AI in crop improvement illustrates its practical benefits and effectiveness.

7.1 Genomic Selection in Maize Breeding

A study conducted by [Research Institution] utilized machine learning algorithms to analyze genomic and phenotypic data from diverse maize populations. The AI-driven genomic selection model accurately predicted yield-related traits, reducing the breeding cycle by 30%. This approach facilitated the development of maize varieties with enhanced drought tolerance and higher yields.

7.2 Pest Detection in Rice Fields

In Southeast Asia, an AI-powered computer vision system was deployed to detect early signs of rice pests using drone-captured images. The system achieved a detection accuracy of over 90%, enabling timely interventions and reducing pesticide usage by 25%. This application contributed to sustainable pest management and increased rice productivity.

7.3 Precision Irrigation in Wheat Cultivation

A precision agriculture project in Australia employed AI-driven sensors and predictive models to optimize irrigation schedules for wheat fields. By analyzing soil moisture, weather forecasts, and crop water requirements, the system reduced water usage by 20% while maintaining optimal yields. This case demonstrates AI's role in resource conservation and efficient farm management.

7.4 Automated Harvesting in Tomato Production

A commercial tomato farm implemented AI-powered robotic harvesters equipped with computer vision and machine learning algorithms. The robots accurately identified ripe tomatoes and performed harvesting tasks autonomously, increasing harvesting efficiency by 40% and reducing labor costs. This example highlights the potential of robotics in modern agricultural practices.

8. Future Prospects

The future of AI in crop improvement is promising, with ongoing advancements poised to further enhance agricultural productivity and sustainability.

8.1 Advanced AI Algorithms

The development of more sophisticated AI algorithms, including deep learning and reinforcement learning, will enable more accurate predictions and complex decision-making processes. These advancements will enhance the precision and effectiveness of AI applications in crop improvement.

8.2 Integration with Emerging Technologies

Combining AI with emerging technologies such as blockchain and the Internet of Things (IoT) can enhance data transparency, traceability, and real-time monitoring. This integration will facilitate more robust and secure agricultural systems, supporting global food supply chains.

8.3 Personalized Farming

AI-driven personalized farming approaches will tailor agricultural practices to specific farm conditions and farmer preferences. Customized recommendations for crop management, breeding strategies, and resource allocation will optimize productivity and sustainability on a per-farm basis.

8.4 Collaborative AI Platforms

The development of collaborative AI platforms that enable data sharing and joint analysis among researchers, farmers, and agribusinesses will foster innovation and knowledge dissemination. These platforms will support collective efforts in addressing global agricultural challenges.

8.5 Enhanced Genomic Editing

AI will play a crucial role in advancing genomic editing technologies, such as CRISPR-Cas9, by identifying target genes and predicting the outcomes of genetic modifications. This synergy will accelerate the development of crops with desired traits, enhancing food security and resilience.

8.6 Sustainable Agriculture Initiatives

AI will support sustainable agriculture initiatives by optimizing resource use, minimizing environmental impacts, and promoting climate-resilient farming practices. AI-driven solutions will contribute to achieving global sustainability goals and ensuring the long-term viability of agricultural systems.

9. Conclusion

Artificial Intelligence is revolutionizing crop improvement by enhancing breeding processes, optimizing crop management, and enabling precision agriculture. The integration of AI technologies such as machine learning, computer vision, and robotics with genomic and phenotypic data analysis has led to significant advancements in developing high-yielding, resilient crop varieties. AI-driven applications offer numerous benefits, including increased efficiency, enhanced accuracy, cost-effectiveness, sustainability, and scalability. However, the widespread adoption of AI in agriculture faces challenges related to data quality, technical expertise, cost barriers, ethical considerations, and system integration. Addressing these challenges through collaborative efforts, investment in infrastructure and education, and the development of inclusive technologies is essential for maximizing AI's potential in crop improvement.

Looking ahead, continued advancements in AI and its integration with emerging technologies promise to further transform agricultural practices, contributing to global food security and sustainable farming. As AI becomes more accessible and sophisticated, its role in shaping the future of agriculture will be increasingly pivotal, ensuring the production of resilient, high-yielding crops to meet the demands of a growing global population.

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ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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Introduction

Ecological engineering can be defined as the practice of joining the economy of society to the environment symbiotically by fitting technological design with ecological self-design. Odum was the first person to use the term "ecological engineering", which can be described as environmental manipulation by man using small amounts of supplementary energy to control systems in which the main energy drives are still coming from natural sources (Odum, 1962). Among the characteristics of the form of engineering, use of quantitative approaches and ecological theory as well as the view of humans as part of rather than apart from nature. Ecological engineering is a conscious human activity and should not be confused with the more recently developed term "ecosystem engineering".

It is an emerging technology to enhance biological control in an agro system by preserving or enhancing its plant diversity or providing adequate refugia for pest's natural enemies. Many adult parasitism and predators benefit from sources of nectar and the protection provided by refuges such as hedgerows, cover crops, and weedy borders. Mixed plantings can increase the diversity of habitats and can provide alternative food sources and shelter to natural enemies.

Habitat manipulation is manipulation of agricultural area and surrounding environment with the aim of conserving or augmenting population of natural enemies. It aims at preserving the natural enemies available in the ecosystem to bring about effective management of the pests of crops. In habitat manipulation we manipulate the agricultural area and surrounding environment with the aim of conserving the natural enemies or modified the cropping system to augment or favour the natural enemies.

Ecological engineering for pest management has recently emerged as a paradigm for considering pest management approaches that rely on the usage of cultural techniques to effect habitat manipulation and to enhance biological control. The cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops. Natural enemies may require food in the form of pollen and nector for adult natural enemies shelter such as overwintering sites, moderate microclimate etc. and alternate hosts when primary hosts are not present. Due to enhancement of biodiversity by the flowering plants, parasitoids and predators (natural enemies) number also will increase due to availability of nectar, pollen, fruits, insects, etc.

Possible ways to Enhance Natural Diversity

Trees and other tall vegetation can provide the vertical structure needed by spiders and birds. Flowering shrubs, herbs, annual and perennial forbs can provide for parasitic ichneumonids and syrphids that feed on flower, nectar and pollen. The syrphids are predators of aphids and are more abundant in areas of high floral diversity and abundance and aphids that feed on goldenrod can be used as alternative prey for ladybird beetles (Coccinellidae) when population of their primary prey is low (Landis et al. 2000).

Chocolate-Box Ecology

Habitat manipulation for enhanced pest control has been referred to by critics as ‘chocolate-box ecology’. Floristically diverse vegetation is added in order to provide adequate nectar, pollen and nutritious diet for natural enemies, this crude approach of habitat manipulation researchers now more commonly screen plant species to determine optimal species or use a range of selection criteria to determine appropriate botanical composition. These approaches reflect that the quality not the quantity of diversity that is important and requires the selection of ‘right kind’ of diversity. A wide range of approaches are being developed by researchers and employed by practitioners to ensure that appropriate forms of diversity are deployed for pest management via ecological engineering (Gurr et al. 2004).

Push-Pull Strategy

Push-pull strategies involve the behavioural manipulation of insect pests and their natural enemies via the integration of stimuli that act to make the protected resource unattractive or unsuitable to the pests (push) while luring them toward an attractive source (pull) from where the pests are subsequently removed (Cook et al. 2007).

Principles of the Push-Pull Strategy

Push-pull strategies use a combination of behaviour modifying stimuli to manipulate the distribution and abundance of pest and/or beneficial insects for pest management. Strategies targeted against pests try to reduce their abundance on the protected resource, for example, a crop or farm animal. The pests are repelled or deterred away from this resource (push) by using stimuli that mask host appearance or are repellent or deterrent. The pests are simultaneously attracted (pull), using highly apparent and attractive stimuli, to other areas such as traps or trap crops where they are concentrated, facilitating their elimination (Cook et al. 2007).

The strategies involve the combined use of intercrops and trap crops, using plants that are appropriate for the farmers and that also exploit natural enemies. These plants were selected following trials in Kenya of potential host and non-host plants (Khan et al., 2000). Stem borers are repelled from the crops by repellent non host intercrops, particularly molasses grass, silver leaf desmodium or Greenleaf desmodium (push), and are concentrated on attractive trap plants, primarily Napier grass or Sudan grass (pull). Molasses grass, when intercropped with maize, not only reduced stem borer infestation, but also increased parasitism by *Cotesia sesamiae* (Khan et al., 1997). Desmodium intercrops also produce these compounds, together with large amounts of other sesquiterpenes, and furthermore, when intercropped with maize or sorghum, suppress the parasitic African witchweed (Striga hermonthica).

Ecological Engineering for pest Management-Above Ground

- Raise the flowering plants/compatible cash crops along the orchard border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the orchard
- Not to uproot weed plants those are growing naturally like Tridax procumbens, Ageratum spp., Alternanthera spp. etc. which act as nectar source for natural enemies,
- Don’t apply broad spectrum chemical pesticides. The plant compensation ability should also be considered before applying chemical pesticides.

Ecological Engineering for Pest Management-Below Ground

- Keep soils covered year-round with living vegetation and/or crop residue.

- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using bio-fertilizers.
- Apply mycorrhiza and plant growth promoting rhizo-bacteria (PGPR)
- Apply Trichoderma spp. and Pseudomonas fluorescens as seed/seedling/planting material, nursery treatment and soil application.

Conclusion

Ecological engineering presents an attractive option for the design of sustainable agro-ecosystems and it is also less risky. This can be complemented by other methods and should not be promoted as a standalone method. Commonly these will employ biological control agents that have been released in classical or augmentative manners. In such instances habitat management holds considerable potential for enhancing the success rates of classical agents, and to maximize the persistence and impact on pest population of augmentative agents.

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INFLUENCE OF CONSERVATION AGRICULTURE PRACTICES ON SOIL BACTERIAL COMMUNITIES UNDER SEMIARID RAINFED AGRICULTURAL PRODUCTION SYSTEM

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Abstract

Soil microorganisms are indispensable for vital soil functions in agroecosystems. Their composition and abundance are influenced by soil and crop management practices. A long-term conservation agriculture experiment with rainfed pigeonpea-castor bean cropping system revealed the predominance of bacterial phyla such as Actinobacteria, Proteobacteria, Chloroflexi, Planctomycetes, Acidobacteria, Bacteroidetes, Verrucomicrobia, and Gemmatimonadetes. Further, CA also resulted in enhanced dehydrogenase, urease, acid and alkaline phosphatase enzyme activities.

Keywords: Conservation agriculture, Castor bean, Rainfed, Microorganisms, Pigeonpea,

Introduction

The major challenges to sustainable agricultural production in India are reduced availability and degradation of natural resources like land, water, and air (Gulati et al 2023). Further, changing climatic conditions such as increased frequency and intensity of droughts, erratic rains, heatwaves, floods etc. are also significantly affecting the crop production (Dhillon and Sohu 2024). Conservation agriculture (CA) is an agricultural management system that involves minimal mechanical soil disturbance, permanent soil organic cover (mulch) and crop rotations (Hobbs et al. 2008; FAO. 2016). It is considered as one of the resources saving technology to improve agricultural productivity and prevent degradation of soils in rainfed areas (Pratibha et al 2021). Soil microorganisms carries out various functions such as organic matter decomposition, biogeochemical cycling of carbon, nitrogen, phosphorus and sulphur, mobilization, solubilization and transformation of nutrients, suppression of pest and diseases (Wang et al.2024; Manjunath et al. 2016 and 2017; Srinivasarao et al. 2018). The crop and soil management practices largely affect the composition and diversity of these soil microorganisms.

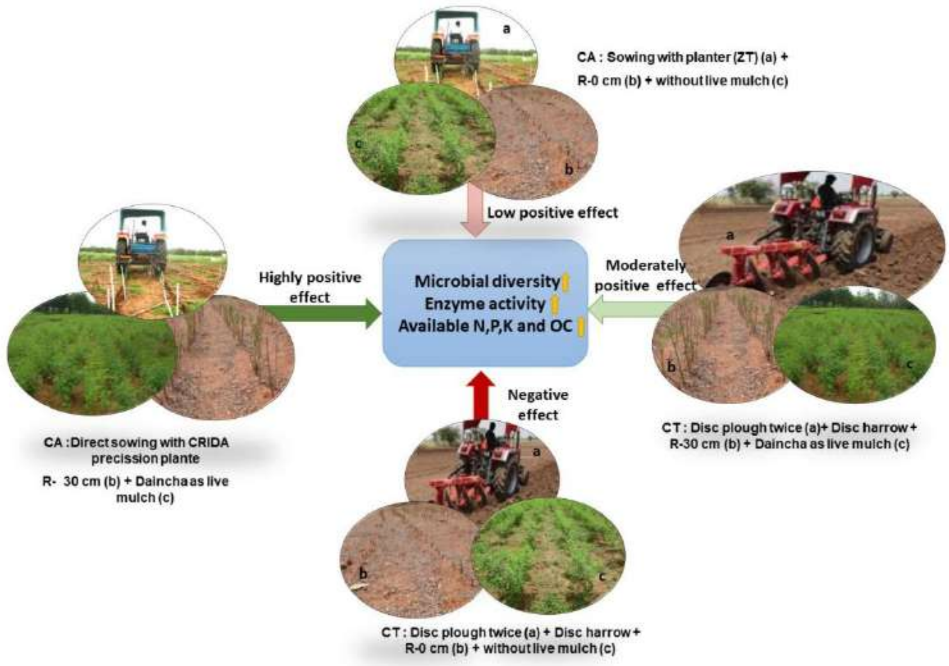

Fig. 1. Effect of tillage and residue management practices on soil microbial diversity and nutrients

Experiment

A long-term conservation agriculture experiment in rainfed pigeonpea (*Cajanus cajan* L.)-castor bean (*Ricinus communis* L.) cropping system under semi-arid conditions revealed the occurrence of different bacterial phyla such as Actinobacteria, Proteobacteria Chloroflexi, Planctomycetes Acidobacteria, Bacteroidetes, Verrucomicrobia, Gemmatimonadetes, Firmicutes, Patescibacteria, Unknown, Armatimonadetes, FBP, Chlamydiae, Entotheonellaeota Elusimicrobia, Euryarchaeota, Nitrospirae, Thaumarchaeota, Thermotogae, Deinococcus-Thermus, Omnitrophicaeota, Fibrobacteres, Dependentiae, Rokubacteria and Latescibacteria .

No tillage recorded higher relative abundance of Actinobacteria, Acidobacteria, Gemmatimonadetes, and Nitrospirae as compared to conventional tillage. Further, Proteobacteria, Chloroflexi, Planctomycetes, Bacteroidetes, Verrucomicrobia, and Firmicutes were higher in conventional tillage and reduced tillage. Conservation agriculture practices enhanced available nitrogen, phosphorus, and potassium contents over conventional tillage.

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NAVIGATING COLD CHAIN STORAGE FACILITIES THROUGH FINANCIAL ASSISTANCE BY NATIONAL HORTICULTURE BOARD

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Introduction

The National Horticulture Board (NHB) was set up by the Government of India in 1984 as an Autonomous organization under the administrative control of Ministry of Agriculture and Farmers Welfare and registered as a society under Societies Registration Act with its headquarters at Gurugram. Presently, NHB has 29 field offices located all over the country. The broad aims and objectives of the Board are to develop production clusters/hubs for integrated Hi-tech commercial horticulture, development of post-harvest and cold chain infrastructure, ensuring availability of quality planting material and to promote adoption of new technologies/tools/ techniques for Hi-tech commercial horticulture etc. In India, the market trends for cold Storage facility providers are witnessing significant growth and transformation. With the rise of e-commerce and the increasing demand for temperature-controlled storage and logistics solutions, companies in the cold storage industry are focusing on expanding their infrastructure and adopting advanced technologies. Additionally, there is a growing emphasis on integrating cold chain networks to ensure seamless transportation and storage of perishable goods across the country.

Capital Investment subsidy scheme for construction/expansion/ modernization of cold storage and storages for Horticulture Produce

Components & Capacity: Credit linked projects relating to Cold Storages including Controlled Atmosphere (CA)and their modernization are eligible for assistance under this component and storage capacity above 5001 MT up to 10000 MT.

Pattern of Assistance: The assistance will be given as subsidy @ 35% of the capital cost of project in general areas.

Cost Norms:

S. No	Description	Cost Norms
1	**Cold storage units Type 1** – basic mezzanine structure with large chamber of > 250 MT) type with single temperature zone	• @ Rs. 8000/ MT for capacity up to 5000 MT. • @ Rs. 7600/ MT for capacity between 5001 to 6500 MT. • @ Rs. 7200/MT for capacity between 6501 to 8000 MT. • @ Rs. 6800/MT for capacity between 8001 to 10000 MT.
2.	**Cold storage units Type 2** – Pre-Engineering Building (PEB) Type for multiple temperature and product use, more than 6 chambers of less than 250 MT and basic material handling equipment	• @ Rs. 10000/ MT for capacity up to 5000 MT. • @ Rs. 9500/ MT for capacity between 5001 to 6500 MT. • @ Rs.9000/MT for capacity between 6501 to 8000 MT. • @ Rs.8500/MT for capacity between 8001 to 10000 MT.

Revision in the scheme guidelines of NHB, including its implementation design, documentation and sanctioning process

The scheme guidelines of NHB including its implementation design, documentation and sanctioning process etc. have further been reviewed and with the approval of competent authority, it has been decided to effect major changes w.e.f. 01.01.2023. NHB will do away with two stage system of IPA and GoC. Now IPA will not be needed for availing benefit under the Scheme of NHB and applicant will apply straightaway for Grant of Clearance (GoC) to NHB after sanction of term loan by bank.

The term loan sanctioned within 3 months from the date of online GoC application to NHB shall be treated valid, however, disbursement of term loan and start of project will be allowed only after issuance of GoC by NHB. GoC will be valid for 3 months for getting disbursement of first instalment of term loan and start of project. Accordingly, the applications in NHB will be dealt in the following manner

1. IPA system will be discontinued from 15.03.2023 and thereafter NHB shall accept applications only for Grant of Clearance with required documents. IPA/GoC applications received prior to the same will be considered as per existing system.
2. The processing of GoC application will be completely digital, including examination and sanctioning. The platform will be augmented with the timeline monitoring systems, so that every step can be monitored as per the pre-set target timelines and alerts can be sent to the processing officer/applicant at regular intervals and escalation matrix can be put in place based on ageing analysis of pendency at officer level.
3. Before making a new GoC Application online on the Web-Portal of NHB, the applicant will have to register after Aadhar authentication through OTP verification. Applicant will be given an option at NHB portal and in case loan for the proposed project is sanctioned under Agri-Infra Fund (AIF) Scheme, the entire loan data of the applicant will be captured as such from AIF portal through API and only remaining details would be required to be filled in by the applicant online and saved at NHB Portal to complete the GoC application of NHB. In case loan is not sanctioned under AIF, the complete application form will have to filled up by the applicant.

4. NHB has prescribed a new short template for DPR and Bank appraisal note (Annexure-I). The template is indicative, and applicant/bank must ensure that the components mentioned in the template are invariably included in DPR or appraisal note.
5. The applicant will have to submit following documents along with the application for grant of clearance: - a. Details Project Report (DPR) and the information suggested in the NHB's prescribed template will only be mandatory. b. Project Land Document along with non-encumbrance certificate c. Bank Sanction letter d. Bank Appraisal Note e. Undertaking (will be part of Application Form in the prescribed format)
6. After application is submitted, an email will be sent to the applicant along with a reply/confirmation link to the financing bank. Concerned bank need to confirm the authenticity of documents online. Based on the confirmation of documents, e.g. bank sanction letter, appraisal note and land documents etc., NHB will issue GoC.
7. Queries on GoC applications, if any, will be communicated to the applicant Bank automatically by system/email by the concerned division within 15 days from the date of receipt of hard copy of the application/documents/bank documents and get the reply from applicant/bank within 15 days and place the application to the approving authority for decision. GoC will be issued by NHB within a period of two months positively.
8. Subsidy claim documents will also be submitted by bank/applicant online.
9. Technical Data sheet for Cold Storages and Protected Structure will be a part of DPR and instead of their appraisal by National Centre for Cold Chain Development or any other agency, it will be mentioned in the GoC Letter that applicant will construct the cold storage/green house as per extant standards/ specifications prescribed by NHB. Similarly, Registration certificate/Deed in case of legal entity will be a part of DPR.
10. NHB shall be timely relying upon financing banks for the examination of project documents.

For more details visit website: www.nhb.gov.in

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UNLOCKING PLANT IMMUNITY: THE ROLE OF DMR 6 IN CROP DISEASE RESISTANCE

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Introduction

As the global population continues to rise, ensuring food security becomes an increasingly urgent challenge for agricultural researchers. Crop diseases are a major threat to achieving this goal, as they can severely reduce yields and jeopardize food supplies. Traditional disease control methods, such as chemical treatments, are proving unsustainable due to their environmental consequences and the growing problem of pathogen resistance. Moreover, resistance conferred by a single R gene tends to be short-lived, as pathogens rapidly evolve to bypass it (Dangl et al. 2013).

In response to these challenges, researchers are investigating genetic approaches to enhance plant immunity without relying on harmful chemicals. One promising strategy involves targeting susceptibility (S) genes—genes that make plants more prone to infection (Thomazella et al. 2021). By disabling these genes, researchers aim to strengthen the plant's natural defenses, offering a more sustainable solution for crop protection. One of the most significant S genes discovered so far is *downy mildew resistance 6* (*dmr6*) (Zhang et al. 2017), which encodes a 2-oxoglutarate-dependent dioxygenase enzyme involved in the regulation of salicylic acid (SA) metabolism, a key hormone in plant defense mechanisms (Liang et al. 2022; Singh et al. 2023). Under normal conditions, DMR6 suppresses immune responses to balance the plant's growth and defense. However, when DMR6 is inactivated, SA levels rise, resulting in increased disease resistance (Yildirim et al. 2023).

This breakthrough has paved the way for the development of disease-resistant crops by targeting S genes like DMR6 in essential crops such as tomatoes, grapevines, and bananas. These advances hold promise for more sustainable agricultural practices and enhanced food security in a rapidly evolving world. In this article, we delve into the role of DMR6, its impact on plant immunity, and the potential of manipulating this gene across various crops

Understanding DMR6 - A Key Player in Plant Immunity

The primary role of DMR6 in the plant immune system is to regulate SA metabolism. SA is a critical hormone that signals the activation of defence mechanisms in plants when they are under attack by pathogens. DMR6 facilitates the conversion of SA into 2,5-dihydroxybenzoic acid (2,5-DHBA), a storage form of SA that can be mobilized when needed (Cai et al. 2022; Liang et al. 2022; Zhang et al. 2017). This process is essential for preventing the over-accumulation of SA, which can lead to unnecessary activation of the plant's immune system and negatively impact growth. However, when DMR6 is inactivated—either through natural mutations or genetic engineering—SA levels rise, leading to the constitutive activation of immune responses (Dong et al. 2019). This enhances defence, makes the plant more resistant to a wide range of pathogens, including bacteria, fungi, and oomycetes.

2-Oxoglutarate-Dependent Dioxygenase Enzyme (2OGD)

2-oxoglutarate-dependent dioxygenases (2OGDs) are a significant class of enzymes involved in various metabolic pathways in plants, including the regulation of SA metabolism through the DMR6 gene. 2OGDs catalyze oxidative reactions, converting 2-oxoglutarate into succinate and carbon dioxide, using iron (Fe) as a cofactor (Gao et al. 2022; Xu et al. 2017). They are involved in hydroxylation and other modifications of various substrates, including nucleic acids, proteins, and secondary metabolites (Thomazella et al. 2021). The 2OGD superfamily is divided into three main classes: DOXA, DOXB, and DOXC. DMR6 falls under the DOXC class, which is crucial for plant metabolism and involved in hormone biosynthesis and secondary metabolite production (Anuradha et al. 2023).

Role of DMR6 in enhancing immunity

Mutations in *dmr6* can confer broad-spectrum resistance against various pathogens. In tomatoes, inactivating the *dmr6*-1 gene enhances resistance to *Phytophthora infestans*, which causes late blight, as well as other bacterial and fungal diseases. Research has identified two orthologs, *dmr6-1* and *dmr6-2*, with *dmr6-1* being crucial for resistance. Using CRISPR/Cas9 technology to inactivate *dmr6-1* has significantly improved resistance to these diseases, indicating a sustainable path for developing disease-resistant tomato varieties that require fewer chemical inputs (Thomazella et al. 2021). Grapevines are threatened by downy mildew, caused by *Plasmopara viticola*, which often necessitates frequent and costly fungicide applications. Simultaneously, editing *dmr6-1* and *dmr6-2* genes in grapevines has shown promising results, with double mutants exhibiting significantly reduced disease severity compared to wild-type plants (Giacomelli et al. 2023). Targeting *dmr6* could enhance disease resistance, reducing reliance on chemical treatments and promoting sustainable grape production. Bananas are also at risk from various pathogens, including Banana Xanthomonas wilt (BXW), a devastating bacterial disease caused by *Xanthomonas campestris pv. musacearum* (Xcm). Studies have underscored the role of DMR6 in banana susceptibility to BXW (Tripathi et al. 2021). Tripathi et al. (2021) reported that *dmr6*-edited banana plants showed enhanced resistance to BXW without any adverse effects on growth. Additionally, there is ongoing research into the potential use of DMR6 in other crops, as summarized in Table 1.

Table 1: List of crops edited for dmr6 genes.

Crop	***dmr6* Gene**	Modification Method	Specific Modification Details	Results/Effects	Applications	Reference
Grapevine	VviDMR6-1, VviDMR6-2	CRISPR/Cas9	Simultaneous knockout of both VviDMR6-1 and VviDMR6-2 using specific guide RNAs (DM1a, DM1b, DM2a, DM2c)	Significant reduction in susceptibility to downy mildew (DM) and increased salicylic acid levels	Enhancing disease resistance in grapevine	Giacomelli et al. 2023
Tomato	SlDMR6-1	CRISPR/Cas9	Targeted mutagenesis of SlDMR6-1 to disable its function	Broad-spectrum resistance against *Pseudomonas syringae* and *Phytophthora capsici*	Developing disease-resistant tomato varieties	Thomazella et al. 2021
Potato	StDMR6-1,	CRISPR/Cas9	Knockout of StDMR6-1 gene	Increased resistance	Improving late blight	Karlsson et al. 2024

	StDMR6-2		specifically	to *Phytophthora infestans*; StDMR6-2 did not affect resistance	resistance in potatoes	
Banana	DMR6 homologs	Gene editing (CRISPR)	Targeted editing of DMR6 homologs to confer resistance	Enhanced resistance against *Xanthomonas* wilt	Developing resistant banana varieties	Tripathi et al. 2021
Sweet Basil	*Ob*DMR6 homologs	Gene editing (CRISPR)	Mutations in DMR6 homologs to improve resistance	Conferred resistance to *Peronospora belbahrii*	Enhancing disease resistance in sweet basil	Hasley et al. 2021
Citrus	CsDMR6	CRISPR/Cas9	Editing of CsDMR6 in "Duncan" grapefruit and Carrizo citrange using two specific guide RNAs	Strong resistance to citrus canker, enhancing overall pathogen resistance	Improving disease resistance in citrus crops	Parajuli et al. 2022

Implications of DMR6 manipulation

One of the most exciting aspects of manipulating DMR6 is its broad applicability across different crops. By inactivating DMR6, researchers can increase salicylic acid levels, enhancing resistance to various pathogens. This approach has proven effective in tomatoes, grapevines, bananas, and other crops, making it a versatile strategy in agricultural biotechnology. The ability to confer broad-spectrum resistance is particularly valuable against rapidly evolving pathogens. Traditional disease resistance methods, such as deploying single resistance (R) genes, can be easily overcome as pathogens adapt. In contrast, DMR6-mediated resistance is less likely to be bypassed since it boosts the plant's overall immune response rather than targeting specific pathogen effectors (Thomazella et al. 2021; Parajuli et al. 2022; Giacomelli et al. 2023). The manipulation of DMR6 also has significant implications for sustainable agriculture. By enhancing disease resistance through genetic improvements, farmers can reduce their reliance on chemical pesticides, lowering the environmental impact and costs associated with farming

(Hasley et al. 2021). This aligns with the goals of precision agriculture, which aims to optimize crop production while minimizing inputs and environmental effects. As the global population grows, the demand for sustainable farming practices will increase, and DMR6 could play a key role in meeting this demand. Its broad applicability makes DMR6 a valuable target for crop improvement programs aimed at enhancing disease resilience (Tripathi et al. 2021). Whether through traditional breeding, genetic engineering, or CRISPR/Cas9 technology, inactivating DMR6 could protect a wide range of crops from disease, positioning it as a critical component of future crop protection strategies.

Conclusion

In conclusion, DMR6 has emerged as a vital gene in regulating plant immunity, presenting significant potential for enhancing disease resistance in crops like tomatoes, grapevines, and bananas. Research indicates that manipulating DMR6 could lead to resilient varieties capable of withstanding pathogen challenges, thereby promoting sustainable agricultural practices and reducing reliance on chemical inputs. As more crops are studied, the potential of DMR6-mediated resistance will expand, paving the way for healthier, more resilient crops in the face of growing agricultural pressures.

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AVOCADO: BUTTER FRUIT / SUPER FOOD

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Introduction

The avocado (*Persea americana*), also known as an alligator pear or butter fruit, it is a type of berry is well known for its distinct biochemical makeup and wide range of health advantages. They grow in warm climates and originating in Central and South America and it is currently found in many parts of the world (Iriarte *et al.*, 2020). Avocados provide a substantial amount of monounsaturated fatty acids and are rich in many trusted source of vitamins and minerals. Avocados are nutrient-dense fruits that have become very popular recently because of their many culinary applications and health advantages (Comerford *et al.*, 2016). Avocado fruits are the pure form of heavy energy-dense fruit because it contains about 80 percent of the water of the total edible part of the fruit and about 6.80 percent of dietary fiber. Research shows that avocado fruit has the same effects on weight control as less fat fruits and vegetables (Bes-Rastrollo *et al*., 2008).

Avocados contain healthy fats, anti-aging, disease-fighting antioxidants and nearly 20 vitamins and minerals (Bhuyan *et al*., 2019). Regular avocado eaters have higher intakes of fiber, vitamins E and K, magnesium and potassium than those who don't eat avocados. Just one avocado provides 40 per cent of the Daily Value (DV) of folate, 30 per cent of the DV for vitamin K and over 20 per cent of the daily value vitamin C. Avocados also contains many minerals. Nearly 30 per cent of the daily value of potassium and almost 20 per cent of the daily value of magnesium, a mineral essential for structural and chemical reactions in the human body, is in this fruit (Ford *et al*., 2020).

Biochemistry of Avocado

1. **Lipid Composition:** Avocados contain a lot of fat, mostly in the form of monounsaturated fatty acids (MUFA), which make up around 70 per cent of their total fat content (Flores *et al*., 2019). Oleic acid, the main monounsaturated fatty acid, is well-known for its positive benefits on cardiovascular health. Avocados also contain trace levels of saturated and polyunsaturated fats. Avocados' distinct lipid profile adds to their creamy texture and range of health advantages (Wang *et al*., 2015).
2. **Carbohydrates and Fibre:** Avocados are mostly composed of dietary fibre and contain very little carbohydrates. The majority of the fibre in avocados is insoluble in nature, which helps to maintain regular bowel motions and stave against constipation. Avocados have a low glycemic index, which makes them a good choice for people who are controlling their blood sugar (Hill, 2015).
3. **Protein Composition:** Avocados are a great source of supplemental protein since they contain all essential amino acids, while not being a substantial supply of protein (Comerford *et al*., 2016). These amino acids are necessary for many biological processes, such as tissue healing and enzyme synthesis (Albaugh *et al*., 2017).
4. **Vitamins:** Avocados are rich in several essential vitamins (Dreher *et al*., 2013)
   - **Vitamin K**: Important for blood clotting and bone health.
   - **Vitamin E**: An antioxidant that protects cells from oxidative damage.
   - **Vitamin C**: Crucial for immune function and skin health.
   - **B Vitamins**: Including B_5 (pantothenic acid), B_6 (pyridoxine) and folate, which are vital for energy metabolism and neurological function.

5. **Minerals**: Avocados include magnesium, which is involved in over 300 metabolic events in the body, including muscle and nerve function, and potassium, which helps regulate blood pressure and supports cardiovascular health (Zuraini *et al*., 2021).
6. **Phytochemicals:** Avocados contain various bioactive compounds, such as (Salazar-López *et al*., 2020)
   - **Carotenoids**: Including lutein and zeaxanthin, which are beneficial for eye health.
   - **Polyphenols**: These have antioxidant properties that help reduce oxidative stress and inflammation.

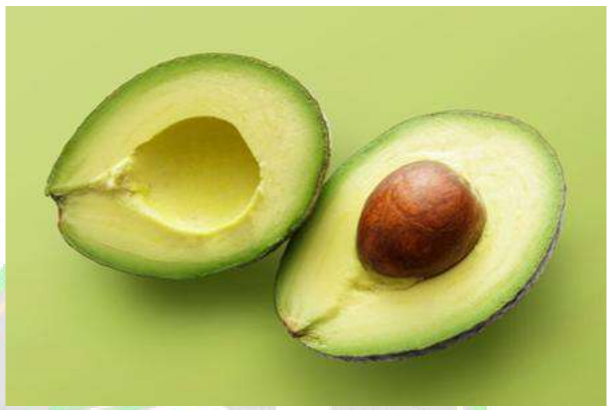
Table 1: Nutritional value of Avocado per 100 g (Maity *et al*., 2023)

SI.NO.	Items	Nutritional value per 100 g (Avocado raw-edible parts)
1	Energy	670 kJ (160 kcal)
2	Carbohydrates	8.53 g
3	Sugars	0.66 g
4	Dietary fiber	6.70 g
5	Fat	14.66 g
6	Protein	2.00 g
7	Thiamine (Vit. B_1)	0.067 mg (5%)
8	Riboflavin (Vit. B_2)	0.130 mg (9%)
9	Niacin (Vit. B_3)	1.74 mg (12%)
10	Panthothenic acid (B_5)	1.39 mg (28%)
11	Folate (Vit.B_9)	81.00 µg (20%)
12	Vitamin C	10.00 mg (17%)
13	Magnesium	29.00 mg (8%)
14	Phosphorus	52.00 mg (7%)
15	Potassium	485.00 mg (10%)
16	Zinc	0.64 mg (6%)

NUTRITIONAL BENEFITS OF AVOCADO

1. **Boosts Satiety:**

Eating healthy fats helps slow stomach emptying, which keeps you full longer than usual and delays the return of hunger. This satisfied feeling is known as satiety. Avocados, whose fat content primarily comes from heart-healthy monounsaturated fatty acids (MUFAs), adding half of an avocado to your meal may significantly boost satiety for up to five hours (Zhang *et al.*, 2022).



2. **Helps to manage body weight:**

The notion that eating fat makes you gain weight is wrong. Eating healthy fats is a savvy weight management strategy. Having one avocado a day in a calorie-controlled diet for 12 weeks, while adding fat and calories, didn't prevent weight loss. Plant-based fats like those in an avocado provide antioxidants and fight inflammation, which has been linked to healthy weight management. Eating avocados regularly may help you to maintain a healthy weight, even without eating fewer calories. Avocados increase your soluble and insoluble fiber intake. Soluble fiber slows down digestion and the absorption of ingested fats and carbohydrates. Insoluble fiber, on the other hand, adds bulk to your stool and helps to eliminate digested food from your intestines. Over time, eating avocados reduces the ratio of visceral fat to subcutaneous fat, which is found just under the skin. This reduction means fat is being redistributed away from the organs. Regular avocado eaters generally have a more nutritious diet consuming more veggies and fruits and less refined foods and have lower body weight and a smaller waist circumference than those who don't eat avocados (Khan *et al.*, 2021).

3. **Protects your heart:**

Consuming an avocado has heart-protective effects by improving your lipid profile. Eating one avocado a day for five weeks reduces total cholesterol, lowers "bad" cholesterol low-density lipoproteins or LDL and raises "good" cholesterol high-density lipoproteins or HDL in people who are overweight or living with obesity. Eating avocado regularly improves your lipid profile lowering triglycerides and LDL and raising HDL (Wang *et al.*, 2020).

4. **Prevents diabetes complications:**

If you have type 2 diabetes or insulin resistance, the higher your blood glucose level rises, the more your body produces insulin to lower your blood sugar. Adding avocado to your meals can prevent insulin and blood glucose levels from rising following the consumption of a meal. Even just adding half an avocado prevents the rise in insulin and glucose. Avocado consumption over time may also reduce belly fat, or visceral fat. Visceral fat cushions the organs in your abdominal region and is tied to a higher risk of type 2 diabetes (Khan *et al.*, 2021).

5. **Boosts nutrients:**

Enjoying avocados at mealtime can help your body absorb more antioxidants from other healthy foods. Pairing avocado with tomato sauce and carrots boosts the absorption of vitamin A, which is a crucial nutrient for healthy skin, vision and immunity (Kopec *et al*., 2014).. Regular avocado eaters tend to consume more vegetables, fruits, and whole grains. People who consume avocados have significantly high intakes of the nutrients like fiber, monounsaturated and polyunsaturated fats, Magnesium, Potassium and Vitamin E (Guan *et al*., 2021).

6. **Promotes healthy digestion:**

Avocados positively impact the gut microbiome inside your digestive tract, home to trillions of microorganisms and their genetic material. A healthy gut microbiome strengthens immune function, fights inflammation and protects against chronic diseases. A 12-week meal plan containing avocados resulted in positive changes to the gut microbiome over the 12 weeks increasing the overall microbe amount and diversity supporting gut health. In other words, the gut didn't absorb the fat into the bloodstream, which may be another way avocados contribute to weight management (Thompson *et al.*, 2021).

7. Increases brain function:

Avocado is rich in a phytochemical called lutein a pigment related to beta carotene and vitamin A. In older adults, eating one avocado a day for six months improved performance on memory tests. However, taking a lutein supplement did not give the same results, so something in the avocado improved brain function (Scott *et al.*, 2017).

8. Protects your eyes:

Lutein and zeaxanthin are antioxidants found in is your eyes, specifically in the macular pigment, which is what gives your eyes the ability to fine-tune your vision. Avocados contain lutein and zeaxanthin Source, two phytochemicals present in eye tissue. They provide antioxidant protection to help minimize damage, including from UV light. The monounsaturated fatty acids in avocados also support the absorption of other beneficial fat-soluble antioxidants, such as beta carotene. As a result, adding avocados to the diet may help reduce the risk of developing age-related macular degeneration. Eating one avocado a day for six months increases the amount of macular pigment that results from the increase in zeaxanthin. In addition, avocados seem to increase the absorption of lutein better than taking just a lutein supplement, likely due to the healthy fats (Eisenhauer *et al*., 2017).

9. Anti-cancer properties:

As pointed out earlier, avocados are rich in antioxidants, extracts of avocado pulp or the fruit have been found to have cancer fighting properties. An extract containing several antioxidants, including lutein, zeaxanthin, beta carotene, and vitamin E, stopped the growth of prostate cancer cells. Studies have not yet assessed a direct link between avocado consumption and a reduction in cancer risk. However, avocados do contain compounds that may help prevent the onset of some cancers. Half of an avocado contains roughly 81 mcg trusted source of folate, 20 per cent of the daily value. Avocados also contain high levels of phytochemicals and carotenoids, which may have anticancer properties.

10. Supporting fetal health:

Folate is important for a healthy pregnancy. Adequate intake reduces the risk of miscarriage and neural tube abnormalities. A person should consume at least 600 micrograms (mcg) source of folate per day when pregnant. One avocado may contain as much as 160 mcg trusted source. Avocados also contain fatty acids that are integral Source to a healthy diet and fetal development.

11. Reducing depression risk:

Avocados are a good source of folate, which plays an important role in overall dietary health. Studies have also found links between low folate levels and depression. Folate helps prevent the buildup of homocysteine, a substance that can impair circulation and delivery of nutrients to the brain. Reviews of past research have linked excess homocysteine with cognitive dysfunction, depression, and the production of serotonin, dopamine and norepinephrine, which regulate mood, sleep and appetite.

12. Osteoarthritis relief

Avocados, contain saponins, these substances may have a positive effect on knee and hip osteoarthritis symptoms. However, researchers have not yet confirmed the long-term effects of saponins in people with osteoarthritis.

13. Antimicrobial action

Avocados and avocado oil contain substances that have antimicrobial properties. Research shows that avocado seed extracts can help defend the body against both *Streptococcus agalactiae* and *Staphylococcus aureus* infections (Saneei *et al.*, 2014).

14. Protection from chronic disease:

The monounsaturated fatty acids in avocados may be beneficial in preventing chronic conditions, such as cardiovascular disease. Meanwhile, suggests that an optimal intake of fiber may reduce the risk of stroke, hypertension, diabetes, obesity and certain gastrointestinal diseases and avocados are rich in fiber. The right fiber intake can also lower blood pressure and cholesterol levels, improve insulin sensitivity, and enhance weight loss for people with obesity (Saneei *et al.*, 2014).

15. **Arthritis and osteoporosis**:

Studies on oil extracts from avocados show they can ease symptoms of osteoarthritis, a kind of arthritis caused by the wear and tear of cartilage and bones. The vitamin K in avocados boosts your bone health by slowing down bone loss and warding off osteoporosis, a disease that weakens your bones and makes them more fragile.

16. **Reduce inflammation from Psoriasis and Eczema:**

Vitamins and antioxidants present in avocado oil, may help to cure and prevent irritated, dry and peeling skin *i.e.* psoriasis and eczema. When applying the oil to the skin it is important to test a patch of the skin first, to ensure that the oil does not cause irritation.

17. **Wound healing rapidly:**

Avocado oil can help to heal the wound more efficiently. In avocado, the oleic acids and essential fatty acids can stimulate to produce the collagen which produces new connective tissue. It can also help to reduce inflammation during the healing process of wounds.

18. **Treats sunburned skin:**

Antioxidants present in avocado oil can reduce sunburn symptoms. All the essential fatty acids, lecithin, beta carotene, protein, vitamin E and vitamin D can protect and heal the skin. It also helps the skin to protect from ultraviolet radiation. Decrease signs of aging: Antioxidants present in avocados are known to decrease aging and keep the skin healthy.

19. **Prevent Chronic Inflammation:**

Chronic inflammation can prevent many disorders *i.e.* arthritis, Alzheimer's and diabetes. Vitamin E present in avocado can reduce inflammation in the human body.

Conclusion

Avocados are a fruit that is high in nutrients and has a special biochemical makeup. They are also very beneficial to human health. They are a great complement to a balanced diet because of their lipid profile, fibre content, vital vitamins and minerals, and bioactive phytochemicals. Frequent avocado eating can improve the health of skin and hair, lower inflammation, boost digestive system function, improve nutrient absorption, and support cardiovascular health.

Avocados are rightfully regarded as a superfood with enormous potential to enhance general health and well-being in light of these advantages.

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BIOCHAR'S POTENTIAL IN ECO-FRIENDLY PEST CONTROL : A PATHWAY TO SUSTAINABLE AGRICULTURE

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Abstract

Biochar, a carbon-rich byproduct of biomass pyrolysis, has gained significant attention for its potential role in sustainable agriculture, particularly in integrated pest management (IPM). This comprehensive exploration delves into the multifaceted applications of biochar in pest management, highlighting its ability to improve soil health, enhance plant resistance, and regulate pest populations. Biochar improves soil structure, water retention, and nutrient availability, creating favorable conditions for beneficial organisms while inhibiting the growth of pests. Moreover, biochar's adsorptive properties can reduce the bioavailability of harmful pesticides, promoting safer and more effective pest control strategies. Studies suggest that biochar amendments may contribute to both direct and indirect pest suppression, making it a valuable tool in reducing chemical inputs and fostering long-term agricultural sustainability. This review critically examines current research, gaps in knowledge, and the potential for biochar to support eco-friendly pest management practices, addressing the environmental challenges posed by conventional chemical pesticides.

Introduction

As global agricultural systems strive for sustainability, finding eco-friendly solutions to manage pests while minimizing environmental harm is becoming increasingly vital. One such promising solution is biochar, a carbon-rich material produced through the thermal decomposition of organic matter in the absence of oxygen, known as pyrolysis

(Lehmann & Joseph, 2009). Historically used in ancient civilizations to enhance soil fertility, biochar has recently gained renewed interest due to its potential applications in modern agriculture, particularly for integrated pest management (IPM) (Glaser *et al*., 2002). Biochar's diverse properties, including its ability to improve soil health, retain nutrients, and modify microbial communities, suggest that it may have significant indirect and direct effects on pest populations (Elad *et al*., 2011). By improving soil structure, increasing water retention, and enhancing nutrient availability, biochar creates a more favorable environment for beneficial soil organisms, such as microbes and arthropods, which play crucial roles in natural pest control (Graber *et al*., 2010). Additionally, biochar's adsorptive properties can immobilize harmful chemicals, reducing the toxicity of pesticides and promoting a safer agricultural environment (Gul *et al*., 2015).

In India, where crop residue burning is a major environmental concern, biochar provides a sustainable alternative to manage agricultural waste. According to MNRE (2020), India produces an estimated 750 million tons of biomass annually, with around 93 million tons of crop residue burned each year, contributing to severe air pollution (Gupta & Dadlani, 2012). Converting this biomass into biochar not only addresses waste management but also presents an opportunity to enhance pest management practices while improving soil health and reducing reliance on chemical pesticides.

Biochar and Soil Health: The Foundation for Pest Control

One of biochar's most significant contributions to pest management stems from its ability to enhance soil health. By improving the physical structure of the soil, increasing water retention, and stabilizing nutrients, biochar creates an environment that fosters the growth of beneficial soil organisms, including microbes and arthropods (Elad *et al*., 2011). These organisms contribute to natural pest control by acting as predators or competitors to harmful pests. Biochar also alters soil pH, reduces acidity, and enhances cation exchange capacity, allowing plants to better access essential nutrients. Healthier soils result in more robust plants, which are less vulnerable to insect damage and disease (Graber *et al*., 2010).

Moreover, biochar can positively influence the rhizosphere, the region of soil directly influenced by plant roots, by increasing microbial activity and diversity (Lehmann *et al*., 2011).

This microbial diversity plays a crucial role in pest management as some soil microbes produce substances that inhibit the growth of harmful pathogens or induce systemic resistance in plants, making them less susceptible to pest attacks (Warnock *et al*., 2007). The enhanced plant vigor that results from biochar application often translates into higher resistance to pests, thereby reducing the need for chemical pesticides.

Direct Effects of Biochar on Pest Populations

While biochar's indirect effects on pest management through soil improvement are well-documented, there is growing evidence to suggest that biochar may also exert direct effects on pest populations. One possible mechanism is biochar's ability to alter the physical and chemical properties of the soil surface, making it less hospitable to certain pests. For example, biochar may absorb allelochemicals—naturally occurring plant compounds that deter herbivores—thereby enhancing the plant's own defenses against pests (Jaiswal et al., 2014). Additionally, biochar can reduce the mobility and availability of soil-borne pathogens by adsorbing harmful chemicals and preventing them from entering the food web (Gul *et al*., 2015).

Studies have also suggested that biochar's porous structure may serve as a habitat for beneficial insects, such as predatory beetles and spiders, which prey on pest species. This habitat creation supports a balanced ecosystem where natural enemies of pests can thrive, contributing to biological control (Rondon *et al*., 2007). Moreover, the presence of biochar in the soil can reduce the reproduction rates of some insect pests, although the mechanisms behind this phenomenon are still not fully understood and require further research (Steiner *et al*., 2010).

Biochar as a Carrier for Biological Pest Control Agents

Another promising avenue for biochar in pest management is its use as a carrier for biological pest control agents, such as beneficial fungi, bacteria, and nematodes. Biochar's porous surface offers an ideal environment for these organisms to colonize and persist in the soil, extending their efficacy in controlling pests (Elmer & Pignatello, 2011). For instance, biochar has been shown to enhance the survival and effectiveness of *Beauveria bassiana*, a fungus used to control a variety of insect pests, by providing a protective habitat and slow-release mechanism for its spores (Mendes *et al*., 2021). This synergistic relationship between biochar and biological control agents opens up new possibilities for integrating biochar into IPM programs. By combining biochar with beneficial organisms, farmers can reduce their reliance on chemical pesticides and promote more sustainable pest control methods that support long-term soil health and biodiversity.

Biochar Production from Crop Residues: A Sustainable Solution for India

India, with its vast agricultural landscape, faces significant challenges in managing crop residues. Each year, an estimated 93 million tons of crop residue are burned, contributing to severe air pollution and greenhouse gas emissions (Gupta & Dadlani, 2012). Converting this biomass into biochar offers a sustainable solution to address both waste management and pest control. According to the Ministry of New and Renewable Energy (MNRE, 2020), India produces around 750 million tons of biomass annually, with a potential surplus of 230 million tons that could be utilized for biochar production. By converting crop residues such as rice husks, wheat straw, and sugarcane bagasse into biochar, farmers can reduce air pollution and enhance soil fertility. Moreover, biochar application can improve pest management in Indian agriculture by promoting healthier soils and reducing the need for chemical pesticides, which are often overused in the region.

Challenges and Future Directions

Despite its promising potential, there are still several challenges to fully realizing biochar's role in sustainable pest management. The effectiveness of biochar can vary depending on the type of biomass used, pyrolysis conditions, and the specific agricultural context. Further research is needed to better understand the interactions between biochar, soil health, pest populations, and plant resilience in different environments. Additionally, while biochar has shown potential in controlling pests and promoting beneficial organisms, more field trials are necessary to determine the long-term impacts of biochar application on pest populations and crop yields. It is also important to investigate the economic feasibility of biochar production and application at larger scales, particularly for smallholder farmers in developing countries.

Conclusion

Biochar represents a promising tool in the pursuit of sustainable pest management, offering both indirect and direct benefits for reducing pest pressures and enhancing soil health. By improving soil structure, promoting beneficial organisms, and serving as a carrier for biological control agents, biochar can contribute to more resilient agricultural systems that rely less on chemical pesticides. Additionally, biochar production from crop residues offers a sustainable solution to address environmental challenges such as air pollution and waste management, particularly in regions like India. As research into biochar's multifaceted applications continues, its potential to support sustainable pest management will likely expand, contributing to a more eco-friendly and resilient agricultural future.

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MOST IMPORTANT INSECT, DISEASE AND THEIR MANAGEMENT IN MANGO CULTIVATION

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Mango mealy bugs

The female lays eggs during may under soil clods around the tree trunk, upto a depth of 5 to 15 cm. the nymphs emerge in December – January and start climbing up the tree where they congregate together and suck juice from young shoots, panicles and flower pedicels. The affected parts dry up and yield is reduced substantially.

The insect can be controlled by the spray of Carbarl (0.2%) or Nuvacron (0.04%) in earliest stage Grease banding is also helpful.

Fruit fly

This is a serious past as the affected fruits become unfit for consumption through the feeding of the maggots in the flesh. The fruit fly lays its eggs in clusters of 150-200 under the skin of the fruit just before ripening. The affected fruits being to rot and drop down.

The control lies in prompt collection and destruction of the damage fruits in hots water or by burying them deep in the soil, poisoned baits placed in wide mouthed containers @ 10 per heactare are helpful in checking the incidence of fruit fly. The file can be controlled by bait sprays of carbaryl (0.2%) + Protein hydrolysate or molasses (0.1%), beginning at egg laying stage.

Red Ants

Live in leaf nests on the tree. They distribute injurious scale all over the tree. Gammexane (5% BHC) with sulphur in the proportion of 2: 1 may be used to destroy them. Dust calcium into nests, spray 0.15% BHC

White Ants

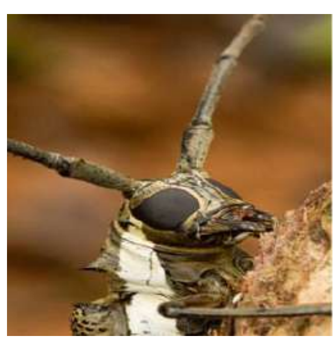
These destroy the young grafts especially during the dry weather in summer. Apply 0.2% DDT around each graft soon he monsoon for control against white ants. Good nitrogenous manures (cakes etc.) may be also being supplied. Soils in the vicinity of the tree should not be allowed to dry. B.H.C. (5%), aldrin, chlorodance or heptachlor may be mixed with the soil in the basin

Stem Borer

This pest tunnels through the main trunk or its branches, weakens the plant and in extreme case, the plant may die. Its presence can be identified by dry hard balls of excreta emerging from the tunned portion. The control lies in cleaning the tunnels with a hard wire, treating with kerosene oil/ creosote/petrol/crude oil or formalin and subsequently, closing the entrance of the tunnel after plugging it with cotton soaked in any of the above substance.

Shoot Borer

The damage is caused by caterpillar which enters the young shoots form the terminal end bore down to a depth of 8 to 10 cm. The affected shoots wilt and dry. It can be controlled by 1 or 2 sprays of carbaryl (0.2%) or nuvacron (0.04%) during the emergence period of vegetative flush.



Mites

Mites minute insects not visible to the naked eye. These attack the leaves and flower which become silvery white and dry up and drop. Sulphur + DDT may be spreyed when the mite menaces increase.

Diseases

Bacterial canker or bacterial spot

This disease is widely prevalent and the infection increase with recurrent rainy weather. However, all varieties are note affected equally. The varieties Bangalore and neelam are more commonly affected, especially in the north. Rarely, this is encountered in Dashehari also. The variety Malika has the drawback, especially when the fruit maturity period happens to be humid and rainy. In dry seasons the incidence is not noticed.

Black Spot

The disease makes its appearance on the leaves as numerous small angular, water soaked area, usually crowded towards the tip and varying from 1 to 4 mm in diameter.

This disease is caused by Bacillus mangiferae. Its satisfactory control is by fine application of Bordeaux mixture (4 : 4 : 50) with addition to sticker between August to December.

Anthracnose

This is fungal disease is also of wide occurrence more especially in human and high rain fall area. The leaves, shoot, inflorescence and fruits are all affected by it. The disease can be controlled by spraying Bordeaux mixture (3 : 3 : 50) Blitox or Phytolan (0.3%), Bavisitin (0.1%) thrice a year i.e., February, April and September.

Sooty Mould

The disease is common in area where “hopper” build up is intense. The fungus develops on the honey dew secreted by the hopper on the leaves, twig and inflorescence. The damage caused in due to restricted photosynthetic activity of the affected leaves. The neem oil inhibits the fungus's growth. Plants that are impacted can be sprayed with insecticidal or dish soap (use one tablespoon for every five liters of water).

Red rust

Red rust or red spot is a common disease on the mango in the tarai and other humid region of India. The disease is caused by cephaleuros virescents. Copper sulphate, Copper oxychloride (0.3%) or Bordeaux mixture (1%) spray have been reported to be quite effective in controlling it.

Dieback

Mango dieback disease symptoms are typically characterized by the drying and withering of twigs from the top down, followed by discoloration, drying, and finally the dropping of leaves. Pruning of diseased twig followed by application of 1% Bordeaux mixture (5 : 5 : 0) has proved useful.

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OPTIMIZING FINGER MILLET YIELDS WITH STRATEGIC MICRONUTRIENT MANAGEMENT

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Abstract

Finger millet (*Eleusine coracana*), a key crop in semi-arid regions, is valued for its nutritional properties and resilience to changing climatic conditions. However, its productivity is often limited by several environmental factors, and a key factor being deficiencies in essential micronutrients. The micronutrient deficiencies can be alleviated by strategic and judicial application of micronutrients that are vital components impacting growth and yield. Different application techniques, including soil and foliar methods, are evaluated in terms of timing, dosage, and interaction with macronutrients. To fully harness the potential of finger millet, it is essential to integrate both organic and inorganic nutrient sources, along with biofortification efforts aimed at improving grain quality and yield.

Introduction

Finger millet (*Eleusine coracana*), is an important staple crop among small millets widely grown in South Asia and Sub-Saharan Africa. Traditional farmers view finger millet as a low-input crop, and it is generally grown under marginal conditions. Despite its ability to thrive in harsh conditions, finger millet often suffers from low yields, largely due to inadequate micronutrient management, thereby leading to limited productivity. Many soils in semi-arid regions, where finger millet is commonly cultivated, are depleted of micronutrients due to factors like continuous cropping and low organic matter application. Micronutrient deficiencies can cause yield losses ranging from 10-30% depending on the nutrient and severity of deficiency. Optimizing nutrient management, including the strategic use of micronutrients, is crucial to enhancing finger millet productivity and ensuring food security in these regions.

Role of micronutrients in finger millet Physiology

Micronutrients play an essential role in plant metabolism. Micronutrients are vital for the proper functioning of various biochemical processes in plants. Although required in trace amounts, their deficiency can severely impact crop growth and yield. Micronutrients like zinc, iron, manganese, and boron are critical for finger millet's development, particularly in soils where these elements are often deficient. Zinc, for example, is a key element in protein synthesis and hormone regulation, and its deficiency in finger millet can lead to stunted growth, poor root development and poor grain production. Iron is essential for chlorophyll formation and photosynthesis, while manganese plays a significant role in nitrogen metabolism and photosystem II efficiency. Boron is critical for reproductive development and seed set in finger millet.

Impact of micronutrient deficiencies on growth, yield and nutritional quality of finger millet

The prevalence of micronutrient deficiencies in finger millet depends on soil type and regional factors. Zinc, iron, and boron deficiencies are common in the alkaline and sandy soils where finger millet is often grown. Zinc deficiency results in smaller leaves, shorter internodes, delayed flowering and reduced seed set, while iron deficiency leads to chlorosis and reduced photosynthetic activity. Boron deficiency primarily affects reproductive development, leading to poor grain formation and lower yields. Besides affecting growth and development, micronutrient deficiencies can have a significant impact on finger millet's yield, and nutritional quality. Zinc and iron deficiencies, for example, not only reduce overall biomass production but also affect the grain's nutritional profile. Severe deficiencies during key growth stages, such as flowering and grain filling, can lead to yield reductions of up to 40%. Additionally, nutrient-deficient grains often contain lower levels of essential micronutrients, which can have implications for human nutrition in areas where finger millet is a staple food. In many regions, these deficiencies are exacerbated by poor soil management practices, continuous cropping without replenishing nutrients, and limited use of organic fertilizers. Addressing these deficiencies is critical for improving both yield and grain quality in finger millet cultivation.

Strategic Micronutrient Management for Finger Millet

To optimize finger millet yields, it is essential to adopt a strategic approach to micronutrient management. This can be achieved through a combination of foliar and soil application methods, ensuring that micronutrients are available to the plant when they are most needed.

Foliar and Soil Application Techniques

Foliar application of micronutrients has proven to be an effective method for addressing deficiencies, particularly during critical growth stages such as pre-flowering and grain filling. Foliar sprays allow for quick nutrient uptake through the leaves, bypassing the challenges of poor soil availability. This method is especially useful for micronutrients like zinc and iron, which may become less available in certain soil types. For example, foliar application of zinc sulphate and boron can significantly boost yields in zinc-deficient soils. Soil application, on the other hand, provides a long-term solution by ensuring a steady supply of nutrients throughout the growing season.For soils deficient in multiple micronutrients, the recommended dose of 12.5 kg of the micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu can be mixed with sand to achieve a total quantity of 50 kg per hectare and applied evenly on the beds, and should not be incorporated into the soil. In iron-deficient soils, the application of ferrous sulfate ($FeSO_4$) has been found to increase yields by 10-18% due to improved grain number and biomass production. Studies have shown that applying zinc sulfate ($ZnSO_4$) at 25 kg/ha can increase grain yield by 15-20%, primarily by improving tiller production and grain weight. Application of micronutrient-rich fertilizers and organic amendments like farmyard manure (FYM) can help replenish soil nutrient levels and improve yield potential over a period of time.

Optimal Timing and Dosage

The timing and dosage of micronutrient application are critical for maximizing finger millet yield. Research suggests that early vegetative stages and pre-flowering are the most crucial periods for micronutrient application. At these stages, nutrients like zinc, manganese, and boron are essential for root development, tillering, and reproductive growth. Over-application of micronutrients can lead to toxicity and nutrient imbalances, so it is important to tailor applications based on soil testing. Field-specific recommendations can help avoid negative impacts and ensure that crops receive the right amount of nutrients at the right time.

Integrating Organic and Inorganic Nutrient Sources

A balanced approach that combines both organic and inorganic nutrient sources can improve nutrient use efficiency and enhance soil health. Organic amendments like compost and farmyard manure not only provide essential micronutrients but also improve soil structure and microbial activity, making nutrients more available to plants. Biofertilizers, which enhance the solubilization and mobilization of micronutrients, offer an eco-friendly alternative to conventional fertilizers. Seed treatment with *Azospirillum brasilense* (a nitrogen-fixing bacterium) and *Aspergillus awamori* (a phosphorus-solubilizing fungus) at a rate of 25 g per kg of seed is highly beneficial for crop growth. If seed dressing chemicals are used, they should be applied first, followed by bio-fertilizers at sowing. For proper coating and inoculation, the bio-fertilizer has to be applied along with the help of a sticker solution made by boiling 25 g of jaggery or sugar in 250 ml of water. After cooling, the sticker solution is applied to the seeds, followed by the bio-fertilizer treatment. The treated seeds are then dried in the shade to prevent clumping and used for sowing. These biofertilizers promote microbial activity in the soil, and increase the availability of micronutrients like zinc and copper, contributing to improved yields in finger millet cultivation.

Biofortification: Enhancing Nutritional Quality

Biofortification is an innovative approach that focuses on breeding crops to increase their micronutrient content. Finger millet is known for its naturally high calcium content. However, through biofortification, the crop's nutrient profile can be further improved to address widespread malnutrition issues, particularly micronutrient deficiencies such as iron-deficiency anaemia and zinc deficiency. Conventional breeding methods, marker-assisted selection, and genetic engineering techniques offer possibility of developing biofortified varieties. High yielding varieties of finger millet bred for higher zinc and iron content, offer a sustainable solution to address both food and nutritional security.

Conclusion

Micronutrient management is a key factor in optimizing finger millet yields and improving grain quality. By addressing common deficiencies, adopting strategic application methods, and integrating both organic and inorganic nutrient sources, farmers can significantly enhance the productivity of finger millet. The research efforts concentrated on development of biofortified varieties holds promise for further improving both yield and nutritional outcomes. Future research should focus on region-specific micronutrient management strategies and the interactions between micronutrients and other essential nutrients, helping to optimize finger millet production in nutrient-poor environments.

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ROLE OF MULCHING IN CROP PRODUCTION

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Introduction

Mulch is derived from the German word "Molsch" which means soft to decay. It is known by gardeners as the use of straw and leaves as a spreading on the soil surface to protect the roots of plant. In agriculture, mulching practices are used for several reasons, but conservation of water and control of soil erosion are main objectives for its used in semi-arid and arid regions. The mulching is application of a covering layer of any materials to the soil surface. Many kinds of materials are used to some extent as mulch for controlling weeds and for other purposes. Different types of mulching materials have been utilized in agriculture both in field and home gardening. Farmers use mulching practices as a method of improvement the cultivation soil condition by covering the surface of soil with many types of materials. The surface of soil is covered with mulch can add soil organic matter, reduce growth of weed, and minimize the soil erosion. Mulch is of two types i.e. organic mulch, living/inorganic mulch and non-living. Organic mulch includes plant leaves, barks, wood chips, grass clipping that can retain the nutrients found in these organic matters. Inorganic material includes black plastic, pebbles and gravels. Mulching is an effective method to be used for the control of weeds. Mulching is a practice of covering the surface of soil, which creates more favorable conditions for growth and development of plant. This prevents the evaporation of moisture formed on the soil and then limits water loss and conserves moisture. Therefore, it helps to maintain soil temperature fluctuations and high retention of soil moisture, improves the properties of soil, as it adds mineral nutrients to the soil and increases the crop growth and yield. The mulch can effectively less loss of water vapors, nutrient loss, control of soil erosion and weed problems.

Types of mulching materials

Organic mulches:

Organic mulches are derived from plant and animal materials such as straw, hay, peanut hulls, leaf mold, compost, sawdust, wood chips, shavings and animal manures. To achieve optimum advantage from the organic mulch, the mulch should be applied immediately after germination of crop or transplanting of vegetable seedling @ 5 t ha-1. Organic mulch are efficient in reduction of nitrates leaching, improve soil physical properties, prevent erosion, supply organic matter, regulate temperature and water retention, improve nitrogen balance, take part in nutrient cycle as well as increase the biological activity.

But organic mulch attracts the cutworms, slugs and insect-pests that eat them. Organic mulch is easily decomposed and require frequent replacements. However, mulch refers to a lot of heat and keeps the soil cool and prevents evaporation as soil and is important in the hot and dry climatic conditions of the soil.

Fig 1.Different types of Mulches

Inorganic mulches:

The inorganic mulches materials do not decompose or they break down gradually after a long time period. The various kinds of inorganic mulch are rocks or gravel, plastic sheeting, landscape fabrics, and rubber mulch. The inorganic materials used as mulch can certainly add attractive value and they work proper well to suppress the weeds.

Inorganic mulch includes plastic mulch and accounts for the greatest volume of mulch used in commercial crop production. Both, black and transparent films are commonly used for mulching. The plastic materials used as mulch are polyethylene films or poly vinyl chloride (PVC). Owing to its greater permeability to long wave radiation it can increase temperature around the plants during night in winter. Hence, polyethylene film mulch is preferred as mulching material for production of horticultural crops. Plastic mulch are of two types:

1. **Photo-degradable plastic mulch**:
   The photo-degradable plastic mulch is used for shorter period because it is destroyed by sunlight.
2. **Bio-degradable plastic mulch**:

The bio-degradable plastic mulch is degraded easily into soil over a time period.

Different colors of plastic film and benefits:

The soil environment can be properly managed by a proper selection of plastic mulch structure, color and thickness. The plastic films are available in various colors including black, transparent, white, silver, blue, red, etc. But the selection of the color of the plastic mulch film depends on specific goals. Generally, the following types of plastic mulch films are used in crop productions:

1. **Black plastic film:** Black plastic film helps in preserve moisture in soil, reduce outgoing radiations and also reduce the weed growth.
2. **Transparent film:** Clear/transparent film increases the temperature of the soil and is preferably used for solarization.
3. **Reflective silver film:** This type of plastic film usually keeps the plant root zone temperature cooler.

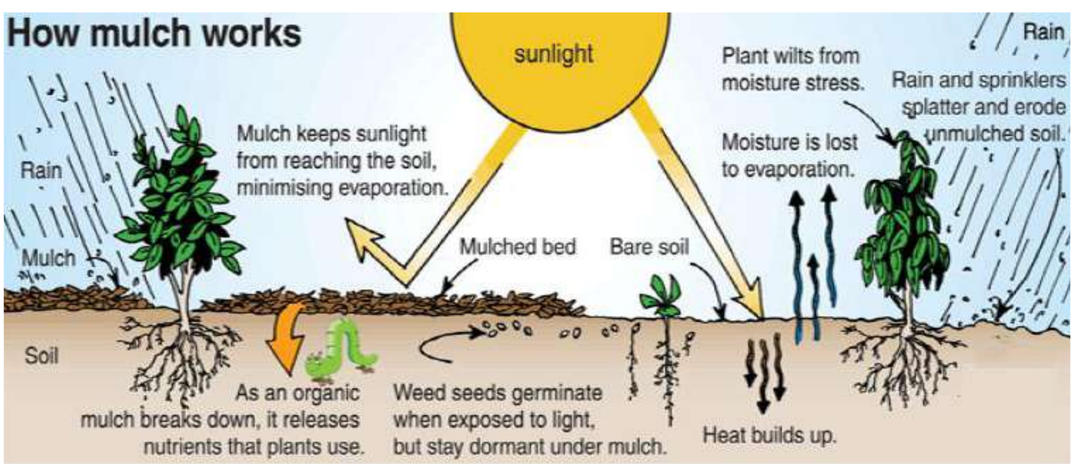

Fig 2: Show the how mulch works

Effect of mulching on soil

Conserve soil moisture

Mulching is one of the important purposes for conservation of soil moisture. The conditions of micro-climate are favorably influenced by optimal soil moisture. When the surface of soil is covered with mulch materials, it helps to minimize evaporation and maximize infiltration of rainwater during the growing season and also helps to control the weed growth. Plastic mulch helps to shed excessive water away from the crop root area during the period of excessive rain fall. This can reduce the frequency of irrigation and the amount of water used. Polyethylene mulch is used in the field, increased temperature of soil especially in early spring season, reduction problems of weed, increased moisture conservation, reduction in certain population of insect-pests, increase yield of crop and greater efficient use of nutrients in the soil. Crop residues or mulch at the surface of soil serve as shade, which acts as a vapor barrier against the loss of moisture from the soil, thereby reducing surface runoff.

Reduced infiltration rate

The crop residue mulch presence on the interface of soil-atmosphere has a directly affects the evaporation from the soil and infiltration of rainwater into the soil. The total intake of water increases due to the formation of loose soil surface through mulching. The mulch cover reduces soil surface runoff and holds more rainwater on the surface of the soil giving more time to infiltrate the soil.

Maintain soil temperature

Mulching decreases the temperature of soil in summer, increases it in winter and prevents extremes of temperature. During the summer, mulching preserves soil moisture due to low evaporation. The temperature of the soil changes according to the ability of mulching materials to transfer and reflect solar energy. Plastic mulching enhanced soil temperature from 0.9 to 4.3°C in the seedling stage, 1.6 to 2.3°C in the bud initiation stage and 0.8 to 1.9°C in the flowering stage.

Reduced fertilizer leaching:

As excessive rainfall is shed drained the root zone, fertilizer loss due to leaching is reduced. This is particularly true in sandy soils. This allows the grower to place more pre plant fertilizer in the row prior to planting the crop.

Addition of organic matter:

Organic mulches return organic matter and plant nutrients to the soil and improve the physical, chemical and biological properties of the soil after decaomposition, which inturn increases crop yield. Soil under the mulch remains loose, friable and leading to suitable environment for root penetration. The organic mulches not only conserve the soil moisture, but they also increase the soil nutrients through organic matter addition.

Effect of mulching on plants

Plant growth and development:

Mulching provides a favourable environment for growth which results in more vigorous, healthier plants which may be more resistant to pest injury. Increase in soil temperature and moisture content stimulate root growth which leads to greater plant growth. Therefore, mulched plants usually grow and mature more uniformally than unmulched plants.

Effect of mulching on weed control:

Mulching practices or covering the surface of soil can control germination of weed seed or physically suppress seedling emergence. The main purpose of mulch practice aims to cut the light of weeds and suppress their growth and development. All types of organic & inorganic mulch cover the soil and performs physical barrier for weeds. Mulching reduces the germination and nourishment of many weeds by providing a physical barrier. The operation of mulching favors reduction of weed growth, weed seed germination and keeps weeds under control.

Promote early harvest:

Warm season vegetables such as cucumbers, muskmelons, watermelons, eggplant, peppers, usually respond to mulching in terms of early maturity and higher yields. An early maturity is probably due to maintenance of favourable temperatures during growing season. Black mulch applied to the planting bed prior to planting will warm the soil and promote faster growth in early season, which generally leads to earlier harvest.

Improve quality and yield:

Mulch helps keep fruits clean from contacting the ground, reduces soil rot, fruit cracking and blossom end rot in many cases. Fruits tend to be smoother with fewer scars. Properly installed plastic mulch helps keep soil from splashing onto the plants during rainfall, which can reduce grading time. The yield and chemical composition of tomatoes, cucumbers, muskmelons, eggplant, were found to be improved. The yield and keeping quality of early potatoes, cabbage and other vegetables may be improved by straw mulch. Application of straw mulch @ 6 t ha-1 increased yield of tomato and okra by 100 and 200 per cent, respectively over control.

Role of mulching in weed management

Reduce weed growth:

Mulching practices or covering the surface of soil can control germination of weed seed or physically suppress seedling emergence. The main purpose of mulch practice aims to cut the light of weeds and suppress their growth and development. All types of organic & inorganic mulch cover the soil and performs physical barrier for weeds. Mulching reduces the germination and nourishment of many weeds by providing a physical barrier. The operation of mulching favors reduction of weed growth, weed seed germination and keeps weeds under control

Insect pest control:

Transparent polyethylene mulch reduced whitefly populations, helped in catching aphids in yellow traps and virus diseases incidence, in comparison to bare soil. Transparent mulch reduced the incidence of virus disease, and delayed by two weeks the onset of virus symptoms compared with the bare soil.

Effect of mulching on soil micro-flora

Mulching stimulates the soil micro-organisms such asbacteria, actinomycetes, fungi, algae and other organisms such as earthworms etc. due to loose, soil conditions well aerated, uniform soil moisture and soil temperatures thus resulting in a high rapid breakdown the organic matter of soil and release of mineral nutrients for crop growth. Under the layer of mulch, earthworms proliferate and help to improve the soil aggregate stability and infiltration etc.

Selection of mulching

The selection of suitable mulching material depends on the types of materials, ecological locations, colors, thickness, perforations and availability of materials, cost-effectiveness, and feasibility of the crop. The comparative characters of the selection of organic and plastic mulching are discussed below:

Table 1: Show the subject organic and plastic mulching

Sl.No	Subject	Organic mulching	Plastic mulching
1	Material Type	Bio-based cellulose, chips, leaf, paper	Acetate, polyethylene, polymeric material

2	Durability	Temporary	Long-lasting
3	Thickness	3-5 cm	15 – 20 m
4	Colors	Natural	Black, silver, white etc.
5	Weed control	Effective but grass material grown weed	High weed competition except the transparent color
6	Solarization	Not effective in some cases	Effective by boosting soil temperature
7	Pest management	Reduced thrips and fungal disease	Reduced thrips, spider mites and whiteflies
8	Availability	Local availability	Not Local availability
9	Priority mulch	Straw (rice and whet)	Black plastic
10	Costing	Cheap	Expensive
11	Labour	Not laborious	Laborious during setting and removing
12	Degradability	Naturally decompose and add nutrients	Discarded and buried that polluted soil
13	Plant growth	Moderate growth	Fast growth
14	Water infiltration	Increases	Restricts water flow

Table 2: Type of mulch used depending on the prevailing conditions

Sl.No	Type of soil / area	Mulch used
1	Rainy season	Perforated mulch
2	Plantation and orchard mulch	Thicker mulch
3	Soil solarisation	Thin and transparent film
4	Weed control in cropped land	Black film plastic mulch
5	Saline water area	Black film plastic mulch
6	Summer cropped land	White film
7	Insect repellent	Silver color film
8	Early germination	Thinner film
9	Sandy soil	Black film

10	Weed control through solarization	Transparent film
11	Nutrient deficient	Stubble
12	Water deficient area	Sea weeds
13	Field prone to soil born diseases	Clear plastic mulch

Table 3: Mulching treatment in different crops.

Sl.No	Crop	Type of mulch used
1	Wheat	Plastic and straw mulch
		Legume mulch
2	Maize	Plastic and straw mulch
		Legume mulch
3	Brinjal	straw mulch
		30 micron, Bi-colored silver, Black plastic mulch
4	Cauliflower	Polythene mulch with different concentrations of OPE(Open Pan Evaporation), RD of Nitrogen and Potassium
5	Tomato	Straw mulch Black polythene mulch, Straw mulch with different combination of drip system.
6	Potato	Straw mulch
		Plastic mulch
7	Onion	Rice straw mulch
8	Garlic	Black polythene mulch, grass mulch
9	Carrot	Lack polythene much, leave mulch, blue polythene mulch, paddy straw much, grass mulch, Sugarcane straw mulch, grass mulch, white polythene mulch
10	Lemon	Bajra straw, maize straw, grasses, brankad, farmyard manure, black polythene

Economic importance of mulch:

Besides beneficial effects on earliness, polyethylene film as a mulch can enhance plant growth and development, increase yield, decrease soil evaporation and nutrient leaching, reduce incidence of pests and weeds, and improve fruit cleanliness and quality yield

Conclusion

The different types of organic and inorganic mulching materials should be extensively used for conservation of soil and moisture/water, soil temperature moderation, soil health maintenance and increased soil productivity. Mulching provides various advantages to production of crop through conservation of soil water, improved physical, chemical and biological properties of the soil, increased soil biological activity. Organic mulch also provides organic matter and mineral nutrients, stimulates soil micro-flora, increases the biological activity of soil and participates in the nutrient cycle. In agriculture, the black plastic mulch is most used for better crop production. The clear/transparent plastic mulch is used in certain areas due to its enhanced the characteristics of soil warming. Weed control beneath the mulch is preventive to its use. Therefore, effect of mulching can be increased production of crop in water deficient areas.

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UNLOCKING NUTRITION: THE BIOFORTIFICATION PROMISE OF PEARL MILLET

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Abstract

Biofortification of pearl millet with increased zinc (Zn) and iron (Fe) levels is an innovative approach aimed at addressing micronutrient deficiencies (MNDs) in vulnerable populations, particularly in regions reliant on pearl millet as a staple food. Genetic improvement can be achieved through traditional plant breeding methods or advanced transgenic techniques. The use of genetic resources, coupled with extensive phenotyping of diverse germplasm collections, enables the identification of elite cultivars with enhanced nutritional profiles. However, biofortification efforts must balance both micronutrient enhancement and grain yield quality.

Introduction

Malnutrition presents a significant global health challenge, impacting millions worldwide. Approximately 828 million people are undernourished, with many others experiencing micronutrient deficiencies, particularly in low- and middle-income countries (WHO, 2022a; Oluwole et al., 2023). While undernutrition remains a critical issue—especially among children, with around 149 million stunted and 45 million wasted—obesity is increasingly prevalent, affecting 1.9 billion adults who are classified as overweight (WHO, 2022b). The COVID-19 pandemic has further intensified these issues by disrupting food systems and limiting access to nutritious foods (UNICEF, 2021). To effectively combat malnutrition, a comprehensive approach is essential, focusing on enhancing food security, promoting dietary diversity, and implementing sustainable policies (Global Nutrition Report, 2021). Biofortification is one promising approach for combating malnutrition as it enhances the nutrient content of staple crops, necessary for their health and development.

Biofortification

Biofortification is the process of increasing the nutrient content of crops through biological means, typically by breeding or genetic modification. The goal is to improve the nutritional quality of crops by increasing the concentration of essential vitamins and minerals like iron, zinc, vitamin A, and others. Unlike traditional fortification, which adds nutrients during food processing, biofortification enhances nutrient levels in crops as they grow, providing a sustainable solution to address nutrient deficiencies in populations that rely on staple crops for their diet.

Pearlmillet – An ideal crop for biofortification

Pearl millet (*Pennisetum glaucum*) is a highly nutritious staple food crop that plays a significant role in the diets of millions of people, especially in arid and semi-arid regions of Africa and Asia. Pearl millet provides a high energy value of 17 MJ/kg, along with quality proteins ranging from 9.5 to 14.41 g/100 g, lipids from 4.8 to 7.1 g/100 g, and significant mineral content, including calcium (16 to 46 mg/100 g), iron (4 to 11.2 mg/100 g), and zinc (2.95 to 7.1 mg/100 g) (Meena et al., 2024). It is rich in dietary fibre and is promoted as a beneficial diet for diabetics. It also contains phytonutrients like polyphenols, flavonoids, and tannins, which have antioxidant properties, contributing to the prevention of chronic diseases like cardiovascular diseases and cancer.

Need to Biofortify Pearl Millet

The need to biofortify pearl millet arises from the widespread issue of "hidden hunger," where caloric intake is adequate, but essential vitamins and minerals are insufficient. While pearl millet is naturally nutritious, it often lacks the necessary levels of key micronutrients to combat malnutrition, particularly in regions where it serves as a dietary staple. Iron and zinc deficiencies are common in these areas, leading to conditions like anaemia, weakened immune systems, and developmental problems. By enhancing the micronutrient content of pearl millet through biofortification, we can significantly improve the nutritional status of populations who thrive on this crop. This approach holds the potential to reduce the prevalence of nutrient-related diseases, such as anaemia and stunting, especially among children and women of reproductive age, ultimately promoting better health and well-being across communities.

Approaches for biofortification

Strategies aimed to develop biofortified pearl millet varieties include conventional breeding techniques, genetic engineering and agronomic practices.

Traditional Breeding

The conventional breeding methods involve hybridization and selection techniques to develop pearl millet varieties with high nutrient levels. The development of high-iron (Fe) and high-zinc (Zn) breeding lines and hybrid parents has been a key focus at ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) and national agricultural research systems (NARS) breeding programs. These breeding programs aim at exploiting natural variation present in the germplasm. This involves large scale screening of pearl millet germplasm for identification of potential donors having high iron and zinc content. The identified breeding lines and parental lines with high iron and zinc are validated and utilised for steadily integrating micronutrient traits into mainstream breeding efforts to enhance the nutritional quality of pearl millet.

The varietal development programme is centred around breeding for composites, while hybrid development employs cytoplasmic male sterility system (CMS). Although several cytoplasmic male sterility sources have been reported, all pearl millet hybrids developed in India are primarily based on A1 cytoplasmic male sterility (CMS). Currently, to improve genetic diversification, the biofortification program employs both A1 and A4 CMS sources for development of biofortified pearl millet hybrids (Govindaraj et al., 2019).

The biofortified varieties and hybrids with a minimum threshold of 42 mg/kg for iron and 32 mg/kg for zinc are evaluated in multi-location trials through All India coordinated research project (AICRP) for Pearl Millet and assessed for their stable performance well across diverse agro-ecological zones, ensuring that farmers, particularly smallholder farmers, benefit from these advancements. This genetic diversification ensures the development of improved varieties that not only exhibit higher Fe and Zn levels but also retain high yield, disease resistance, and adaptability to challenging growing conditions.

Genetic Engineering

Genetic engineering for biofortification involves using biotechnological methods to enhance the nutritional content of crops, such as increasing levels of essential micronutrients like iron and zinc. By employing genome editing technologies, researchers can introduce or modify specific genes responsible for nutrient uptake and metabolism. This approach enables the development of crop varieties with improved nutritional profiles, addressing deficiencies in diets and contributing to better health outcomes in vulnerable populations.

However, research on identification of QTLs and candidate genes for elevated levels of Fe and Zn in pearl millet is limited currently, owing to resource constraints such as lack of a reference genome. Further adequate information on genes involved in the Zn and Fe pathways in pearl millet is essential to target genes via genetic engineering. Due to these limitations, limited progress has been made so far on the nutritional enhancement of pearl millet grains via genetic engineering technologies

Agronomic practices

Biofortification of pearl millet can also be achieved through agronomic practices that involves enhancing its nutritional content, particularly iron and zinc levels, by implementing practices such as improving soil health with organic matter and micronutrient fertilizers, optimizing water management for better nutrient uptake, and selecting high-nutrient varieties. These combined efforts can significantly improve the nutritional profile of pearl millet.

Biofortified pearl millet varieties and hybrids in India

Continuous breeding efforts have resulted in release of several biofortified pearl millet varieties and hybrids. Dhanashakti, was the world's first high-iron (Fe) pearl millet variety, developed from ICTP 8203, a disease-resistant, early-maturing, large-seeded, and high-yielding open-pollinated variety cultivated in India since 1990. This variety released during 2014 for commercial cultivation in India, exhibited 9% higher iron content (71 mg/kg) and 11% higher grain yield (2.2 t/ha) compared to its parent variety. Since then, several biofortified pearl millet varieties such as ICMV 221 Fe 11-2, IABV04 and hybrids including AHB 1200 Fe, AHB1269Fe, HHB 299, HHB311, RHB233, RHB234, Phule Maha Shakti, Moti Shakthi, Jam shakti, Sawaj Sakthi, VMPH7, HHB67Imp2 have been released for commercial cultivation in collaboration with state agricultural universities. These cultivars contain over 70 mg of iron and 35 mg of zinc per kilogram, enhancing their nutritional value (Govindaraj et al., 2019; Yadava et al., 2020; Hariprassanna et al., 2023)

Challenges and Future Prospects

The success of biofortification depends heavily on the genetic diversity available within the crop's gene pool. Despite the availability of diverse germplasm in pearl millet, breeding for micronutrient enhancement faces challenges. The concentration of Fe and Zn in grains is influenced not only by genetic factors but also by environmental conditions, such as soil mineral composition. This interaction between genotype and environment (GxE) makes it necessary to conduct multi-environmental trials to ensure the stability of the micronutrient traits across different growing conditions. A major bottle neck in complimenting conventional breeding with advanced molecular and gene editing technologies for pearl millet biofortification is the lack of a reference genome, which has limited the ability of researchers to precisely target genes associated with increased Fe and Zn content. However, recent efforts by a pearl millet sequencing consortium are expected to produce a reference genome, which will greatly enhance the precision of breeding programs. Once available, this resource will facilitate more effective identification of QTLs and candidate genes, accelerating the development of biofortified varieties. The balance between improving micronutrient content and maintaining yield is another critical challenge. High-yielding varieties are essential for ensuring food security, and any reduction in grain weight or yield as a result of biofortification efforts may hinder adoption. Therefore, breeding programs must carefully balance these traits to create elite lines that are both nutritionally superior and agronomically viable.

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FERMENTED MILK PRODUCTS SECRET FOR STAYING YOUNG NATURALLY

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Introduction

From the time immemorial, milk and milk products were used to a large extent in India in the form of panir, dahi (curd), butter, buttermilk, ghee, etc. The people in those days were healthier and lived longer even beyond a hundred years. Lord Krishna loved butter, Mother Yashoda used to churn curd, make butter and store in earthen pots. So the culture of fermented milk products started from a very ancient time. Ageing is a truth, which everyone has to go through in their life time. Nothing in the world can cease that. But it is possible to reduce its rate so as to stay younger for a longer time, by the consumption of certain food, chemicals or medicines. The best of these is by the consumption of naturally available foods.

Every living being takes in oxygen, for their survival. This cause oxidation which is a main cause of ageing. Antioxidants reduces oxidation and minimise ageing leading to sustained youth fullness. How can we have the se antioxidants that is safe for the health? Here comes the importance of fermented milk products.

Importance of fermented milk products

Milk when fermented by useful bacteria (mainly the Lacticacid bacteria) converts it into nutritious and valuable products like curd, yoghurt, buttermilk etc. The sugar in milk , lactose is converted to lactic acid by the action of these bacteria leading to a sour ,acidic taste and products that are entirely different from milk. These products having the live bacteria, possess antioxidants. Consuming these products frequently can reduce ageing, improve health and keep the Person young. So we have the see antioxidants that are available naturally, then what for should we run behind the chemicals?

Milk is a completely nutritious food. Many value added products can be prepared from milk. The milk products can be classified into five types according to its method of preparation:

1. Fermented milk products Eg.curd, yoghurt, Buttermilk
2. Heat dessicated milk products Eg.peda
3. Acid coagulated products Eg.Paneer
4. Fatrich dairy products Eg.ghee
5. Frozen dairy products Eg.Ice cream

The products obtained by the fermentation of milk by specific bacteria at a specific temperature and humidity are known as fermented milk products. The Fermented Milk Products are the sources of many live bacteria which are helpful and useful for the body, known as the probiotics .Probiotic foods containing these live useful bacteria possess antioxidants that help to reduce ageing ,enhance digestion and improve the health of the consumer.

Lactic acid bacteria is the main content of the probiotic foods. Even doctors prefer tablets having live lactic acid bacteria for diseases related to the digestive system.

The Advantages of the Fermented Milk Products

1. The presence of useful live bacteria in these products help in digestion and also treat diseases related to the digestive system.
2. These products have good medicinal value.
3. These are rich in nutrients.
4. Antioxidants present in these products reduces ageing thus aids to stay young. Let us go through the preparation of fermented milk products.

CURD:

CURD is the most popular and common milk product. It is easily digestible. Itis good even for the babies and old age people. It is the cheapest and easiest to prepare milk product.

Method of preparation of curd:

Milk is boiled and cooled to 30to35degree celsius. To this starter culture is added and mixed well. This is kept at the same temperature for 8 to 12 hours. The temperature at which the starter culture is added is very important. If either it is too low or too high , the curd won't look or taste good. To prevent the increase of acidity, the curd is immediately transferred to a refrigerator at a temperature of 4 degrees celsius. It is desirable to prepare curd in mud vessels.

YOGHURT:

Yoghurt is a miraculous milk product that got introduced from the western countries to India. It is a product that possess the most beneficial micro- organisms. It possess antioxidants, has medicinal effect, nutritional benefits and anti-ageing effect.

It is a product having many health benefits, as it contains the bacteria StrptococcusthermophilesandLactobacillusbulgaricusintheratio1:1.This product is known for:

1. Increasing the longevity.
2. Decreasing ageing.
3. Good for health.
4. Reducing diseases related to digestion.
5. Easily digestible.
6. As acidity is low in yoghurt when compared to curd, Ulcer patients can also readily use this product.

Method of preparation:

Heat milk to 90 degrees for 5 minutes and then cool to 45 degrees. Add 1% Cultureat45degreesandincubatethis at the same temperature. After it gets set, it is transferred to the refrigerator@5 degrees or below to prevent the increase of acidity. Yoghurt prepared in this way is called as plain yoghurt. It is good and tasty to consume plain yoghurt with cut fruits.

Sugar, flavours, fruit pulp and colours when added to the plain yoghurt will change it to another product, flavored yoghurt. Plain yoghurt is better than flavoured yoghurt as it does not contain sugar, artificial colours and flavours.

SHRIKHAND

Shrikhand is a semi soft, sweetish sour whole milk product prepared from lacticfermentedcurd.Thecurdispartiallystrainedthroughaclothtoremove the whey and thus produce a solid mass called chakka (in hindi),the basic ingredient for shrikhand. Chakka is mixed with the required amount of sugar, colour, flavor etc. to yield shrikhand. This product is quite popular in the western regions of India.

Method of preparation

Milk is heated to 90 degrees and cooled 28 to 30 degrees. To this about 0.5 to 1% Streptococcus lactis is added and mixed well. This is kept for about 15- 16 hours at the same temperature.When curd is set firmly (07-0.8% acidity),it is broken and placed in a muslin cloth bagan dhung on a peg for there moval of whey for 8to10 hours. The curd may be gently squeezed for whey drainage. The solid mass thus obtained is called chakka.

The chakka obtained is then admixed with sugar and well kneaded for uniform mixing. Colour, flavor and fruit pulp may also be added. The product now obtained is called Shrikhand. Shrikhand has a delicious sweet is sour taste. It can be consumed as a dessert too.

BUTTERMILK

Buttermilk is also a fermented milk product that can cool the body and also has nutritional and health benefits. It can be prepared by churning curd at a slight lower temperature leading to the formation of butter and buttermilk. It is very good to consume especially during hot summer. Water, salt, ginger, green chillies and curry leaves can also be grinded and added to the buttermilk to get the product sambharam, which is spicy and slightly sour. Sambharam is a traditional refreshing fermentedmilk product of Kerala, used from the olden times.

Conclusion

The use of milk and milk products for health and youthfulness is much better than doing so using chemicals and artificial substances at least these are natural and easily available, both in villages and cities. Hence it should be utilized to the maximum for staying healthy and young. So make these products a part of your daily diet and feel the difference. Consume Fermented Milk Products, Stay healthy, Stay young always.

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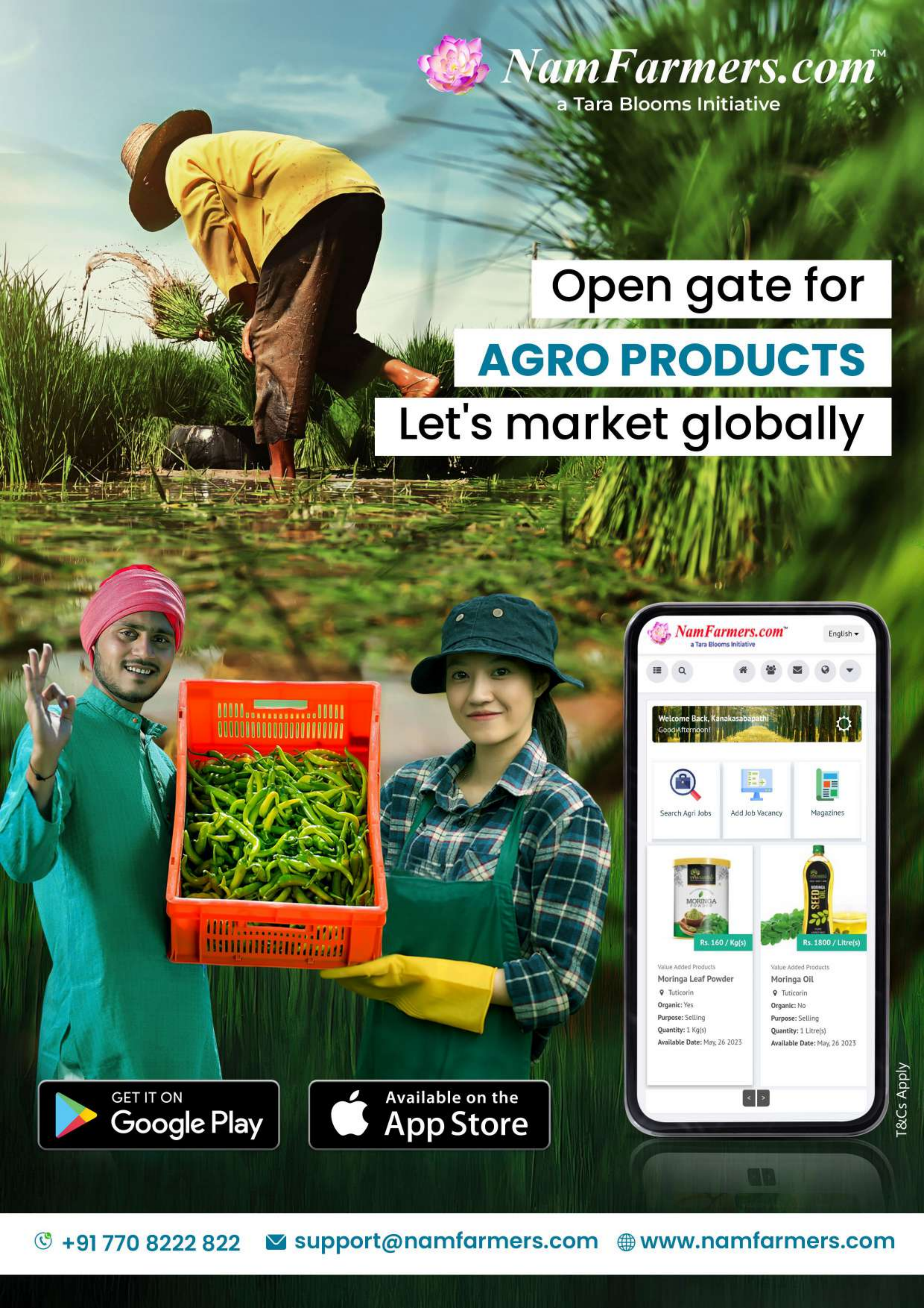
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