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AgriGate

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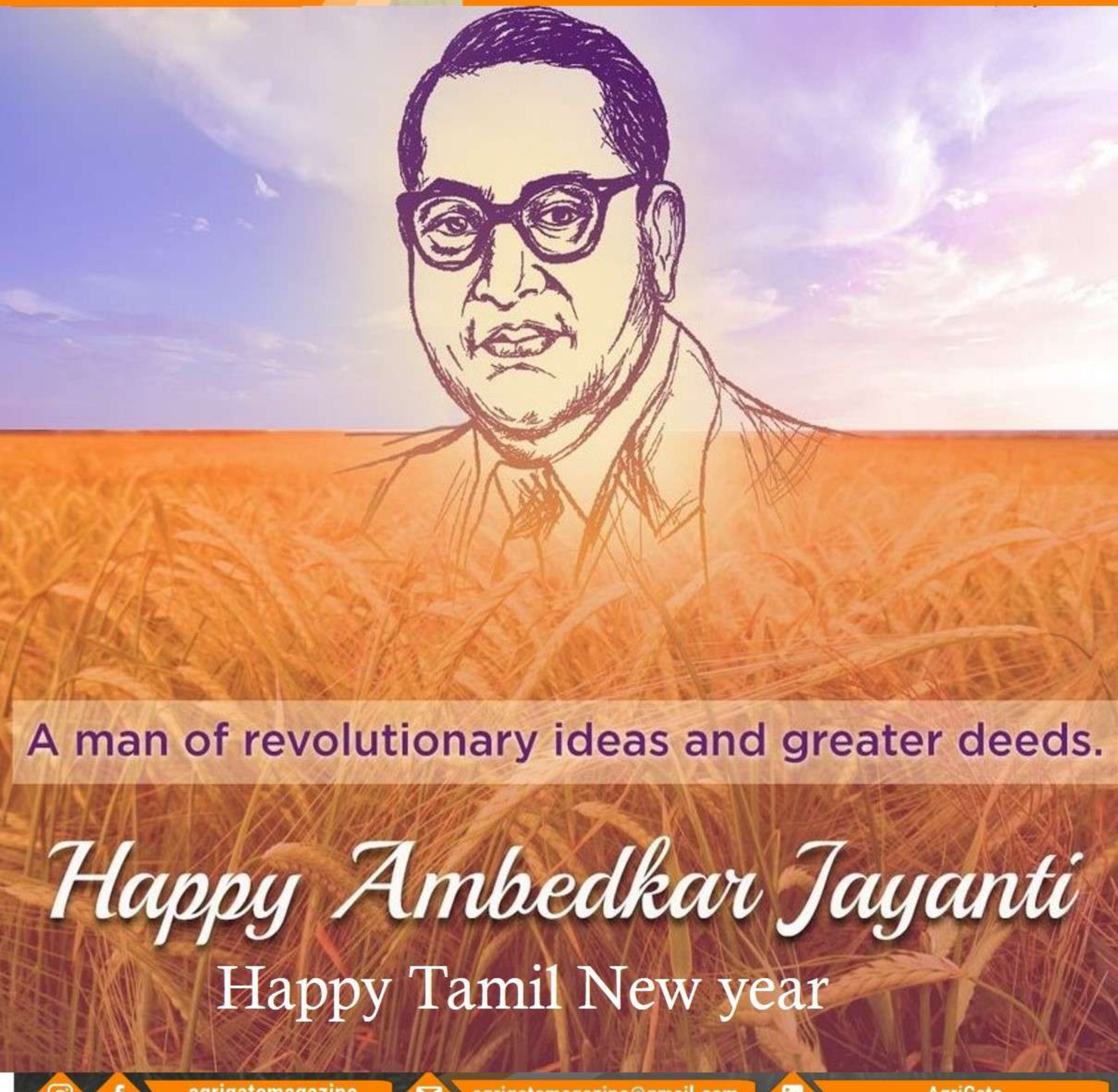
An International Multidisciplinary Monthly e-Magazine



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From the Desk of Editor-in-chief

April 2024|Vol. 04 |Issue No. 04

I would like to introduce the launch of **“AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 04 Issue No. 04 – April 2024”** with immense pleasure. Ourteam is privileged to dedicate this issue to **Tamil Society and B.R. Ambedkar**. The first day of the year on the Tamil calendar is called Puthandu, commonly known as **Tamil New Year**. This celebration usually falls on the April 14 of the Gregorian calendar. The same day celebrates the **birthday of Baba Saheb Bhimrao Ambedkar**, an Indian politician, and social rights activist.

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

Volume: 04 Issue No: 04

SUMMER VEGETABLES: BASIC REQUIREMENTS FOR CULTIVATION AND HEALTH BENEFITS

Article ID: AG-VO4-I04-01

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Introduction

Summer is the ideal time of year to cultivate a variety of vegetables. Summer vegetables that thrive in warm regions, long days, and full sunlight do well in the scorching Indian summer. The summer season in India runs from March to May. Eating seasonal veggies is more important because summertime brings with it a number of health issues, such as skin allergies, dehydration, and vitamin deficiencies. It keeps health problems at bay and guarantees that the body feels good during the hottest months. Summer vegetables are short-season crops that are often planted in the months of Rabi and Kharif. These vegetables, sometimes known as Zaid crops, exhibit increased rates of vegetative and reproductive growth during long days with warm, dry weather, leading to fruiting and flowering. For optimal growth, summer vegetables require a minimum of 6 to 8 hours of direct sunlight and the ideal soil temperature.

Summer vegetable growing calendar for India

Common Name	Scientific Name	Family	Sowing Time	Temperature
Cucumber	*Cucumis sativus*	Cucurbitaceae	March to July	25 to 35°C

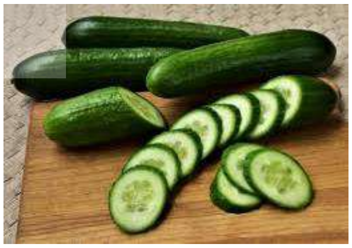
Brinjal	*Solanum melongena*	Solanaceae	February – April	15 -32°C
Bottle Gourd	*Lagenaria siceraria*	Cucurbitaceae	January – March, September–December	18-22° C
Pumpkin	*Cucurbita moschata*	Cucurbitaceae	May – July	25-28°C
Spinach	*Spinacia oleracea*	Amaranthaceae	Mid-February-April	25-30°C
White Onion	*Allium cepa*	Amaryllidaceae	February – July	21-26°C

Crops to produce in the summer

The greatest summer veggies to grow in India are listed below, along with all the cultivation practices

Cucumber

Cucumbers require plenty of sunshine, long, warm days, and moisture because they are a subtropical crop. **The origin of cucumbers is India**. It is a climbing plant often used as a summer vegetable in India.



Description

Stem: rough, succulent, trailing stem with branched tendrils

Leaf: The plants have huge leaves that are triangular in shape and hairy, with three to five pointed lobes

Flower: Five-petaled, yellow flowers. Cucumber vines produce staminate (male) and pistillate (female) flowers (male).

Fruit: cylinder-shaped, with a light complexion and dark green skin.

Basic requirements for cultivation

- ✓ Requires porous, well-drained, and rich in organic matter and plant nutrients.
- ✓ It is ideal to plant it in an area with lots of sunlight, spacing it 36–60 inches apart (12–inches apart for trellised plants).

  To maintain an even moisture level in the soil, regular irrigation is necessary.

  To improve the soil condition, organic matter has to be added
- ✓ Cucumbers grow quickly if given minimal care.

Health benefits

- Cucumbers contain plenty of water (96%), which hydrates body. The fiber prevents constipation.
- Beta carotene and other antioxidants in cucumber help to fight against free radicals, which cause disease, thus immunity will be strengthened
- Cucumbers are low in calories and high in nutrients. Eating cucumber makes feel full and does away with hunger pangs, thus helps in reducing weight
- Vitamin K helps blood clot and maintains bones strong. Vitamin A supports the immune system, eyesight, and reproductive health. It is perfect for the heart, lungs, and kidneys.
- Applying cucumber to skin might reduce skin damage, discomfort, and sunburn-related oedema.

Brinjal

Brinjal is the **vegetable of summer** that is most frequently grown in India.It is also known as eggplant. However, it may thrive in dry areas with minimal watering because of its hardiness. Commonly known as Ringna (Gujarathi), Begun (Bengali), Badane (Kannada), Baingan (Hindi), and other names are used to refer to it.

Description

Stem: With an upright, bushy stem occasionally armed with spines, eggplant is typically planted annually. Brinjal is a relatively small plant that can reach a height of 1.5 m.

Leaf: Large, oval, and barely lobed leaves.

Flower: The typical solitaire pendant violet flowers measure around 5 cm (2 inches) wide.

Fruit: The fruit is a sizable egg-shaped berry with a glossy surface that ranges in colour from dark purple to red, pink, yellowish, or white and is occasionally striped.

Basic requirements for cultivation

- High-yield, fertile, well-drained soil is preferred by the crop. In clayey soils, crops take longer to mature than those sown in sandy soils.
- It needs a long warm growing season because it is grown in the warm season.
- Spacing: Long-fruited types typically have a spacing of 60 × 45 cm, round variants 75 x 60 cm, and high-producing varieties 90 x 90 cm.

Health benefits

- Eggplant is extremely low in calories and has neither cholesterol nor fat. It contains a lot of dietary fibre, which makes our stools more voluminous and aids in efficiently removing waste from our bodies. Fiber can lower blood sugar by slowing the rate of digestion and absorption of sugar in the body. Slower absorption keeps blood sugar levels steady and prevents spikes and crashes.
- Eggplant is rich Vitamin B1 and copper. Other nutrients like manganese, vitamin B6, niacin, potassium, folate and Vitamin K are also found in good quantities.
- Eggplant or brinjal helps our brain to receive blood rich in oxygen and, thus, help neural pathweays to deveop. This, in turn, improves our memory and the ability to think analytically.Additionally, it aids in halting the expansion of malignant cells and tumour formation.

Bottle gourd

The bottle gourd, or *Lagenaria siceraria*, is a climbing or running vine in the gourd family (Cucurbitaceae) that is also known as the white-flowered gourd or the calabash gourd.

Description

Stem: Annuals with hairy stems, long forked tendrils, and a musky scent, bottle gourd vines proliferate.

Leaf: The bottle gourd’s leaves have smooth borders, a few large lobes, or undulating margins and can reach up to 15 inches wide. The thin hairs, especially on the underside, give leaves a velvety touch.

Flower: The flowers have to spread petals up to 4 inches in diameter. They are white and attractive.

Fruit: Bottle gourds come in a fantastic variety of colours and shapes. A fruit with white flesh and white seeds with pale green skin. They might be extended, slender, tiny, bottle-shaped, or thick and rounded.

Basic requirements for cultivation

- It needs sandy loam moisture soils with a pH range of 6.5 to 7.5, rich in organic matter with adequate drainage.
- This plant needs hot, humid temperatures to be grown. It grows best in a temperature range of 20°C. to 32 °C.

  The "dabbling" approach is used to plant vegetable seeds at a distance of two to three x 1.0 to 1.5 meters. Two to three seeds are usually planted in a trench that is 2.5 to 3.0 cm deep.

Health benefits

- *Bottle gourd is a hydrating and nutritious vegetable with numerous health benefits. Its high water content helps maintain hydration, while being low in calories makes it suitable for weight management.*
- *It is rich in fiber, vitamins, and minerals, promoting digestion and overall health.*
- *Bottle gourd's antioxidant properties support immunity, while its compounds aid liver health and its potassium content helps regulate blood pressure.*

Pumpkin

It is a famous vegetable crop in India grown during the rainy season. It is a member of the Cucurbitaceae family and is also known as "HalwaKaddu" or "Kaddu" in Hindi. The second-largest producer of pumpkins is India.

Description

Leaf: Large, lobed, hairy pumpkin leaves develop on hollow stems. They have a somewhat rounded form and frequently have serrated edges. There are three or more veins on them. Depending on the type, they could be light or grey-green in hue instead of the usual dark green.

Flower: The flowers are stunning, funnel-shaped, and have an intense orange or yellow hue. They could be about 4-5 inches in diameter.

Fruit: Pumpkins can be oblate, spherical, or oblong and range in colour from yellow to orange. Some have a white rind and are smooth, typically just mildly ribbed or wrinkled. The ridged, angled, and hard, woody fruit stem.

Basic requirements for cultivation

- It needs loamy soil rich in organic matter and good drainage. For growing pumpkins, the best soil pH is 6-7.
- The seed needs to be planted at a depth of roughly 2.5 for best growth. Plant pumpkin seeds in rows separated by 1.5 to 2 metres, and a minimum of 1 metre between each plant.

Health benefits

- Pumpkins are packed with skin-friendly nutrients, including vitamins C and E, as well as beta-carotene, all of which play an important role in the health of our skin.
- The orange colour of pumpkins indicates beta-carotene content, which is converted to vitamin A when consumed. Vitamin A plays an important role in promoting immune function. Vitamin C also contributes to immune activity facilitating immune cell activity and increasing white blood cells.
- Metabolic syndrome is the medical name for a combination of conditions including diabetes, obesity and high blood pressure. The diets high in carotenoids, which are pigments found in fruit and vegetables that give them their orange, yellow and green colours, may help prevent the development of metabolic syndrome.
- The antioxidant properties of carotenoids, vitamins A and E, all of which are found in pumpkin, may protect against certain cancers, such as breast cancer.

Spinach

Spinach is a hardy leafy annual plant from the amaranth family (Amaranthaceae) that is eaten as a vegetable. It is native to central and western Asia.

Description

- It can grow up to 30 cm tall and is an annual plant. The leaves are simple, alternating, oblong to triangular, flat, or curled with whole or coarsely serrated edges and dark green leaves. Larger leaves are found at the plant's base, and smaller leaves are located higher on the flowering stem. The leaves range from 2 to 30 cm long and 1 to 15 cm wide.
- The blooms can grow alone or in groups called cymes, spikes, or panicles. The bracteate flowers have 4-5 average petals that are frequently fused. There are 1 to 5 stamens. Three to

five connected sepals together up a hypogynous ovary. They are unassuming, yellow-green, and 3–4 mm in diameter. When fully grown, they develop into a small, complex, lumpy fruit cluster 5–10 mm across and containing several seeds.

Basic requirements for cultivation

- The sowing season lasts the entire year, with the exception of December and February.
- Requires well-drained soil rich in organic matter, such as compost or composted manure, and with pH between 6.5 and 7.
- Requires partial shade to grow well
- Do not over water, because spinach grows best in colder climates
- Use a plant-to-plant distance of 5–10 cm and a row-to-row distance of 25–30 cm. Sow seed at a depth of 3-4 cm.

Health benefits

- Spinach is a powerhouse of goodness, rich in plant pigments chlorophyll and carotenoids. As well as being anti-inflammatory, these plant compounds are important for healthy eyesight, helping reduce the risk of macular degeneration and cataracts.
- Spinach is an excellent source of vitamin K, as well as being a source of bone-friendly magnesium, calcium and phosphorus.
- Spinach is packed with plant compounds called polyphenols. The vitamin and polyphenols content explain the cancer-protective properties of spinach.
- Spinach is a useful source of insoluble fibre. This type of fibre promotes the passage of food waste through the intestines and supports gut health and immunity.
- The intake of spinach may reduce the adverse effects of a high-fat diet on the gut microbiome, blood fat profile and cholesterol built up in the liver. Thus reduce the adverse effects of a high-fat diet
- Spinach have anti-stress and anti-depressant properties, as it has been found to lower the stress hormone, cortisol, and increase neurotransmitters that regulate mood such as glutamate and glutamine

White onion

Indian onions are harvested twice a year, from November to January for the first harvest and from January to May for the second.

Description

Stem: The plant's stem is a flattened disc at the base, and the tubular leaves' overlapping sheaths create a pseudostem. The height of an onion plant is 50 cm.

Leaf: There are 3 to 8 leaves per plant, which can be erect or oblique.

Flower: On stalks, the onion plant develops clusters of pink or white blooms.

Bulb: Bulbs grow in clusters of 3 to 18 per plant, and their shape is typically oval, though it can vary. A membrane that transforms into a papery sheath covers the bulb to keep it safe.

Basic requirements for cultivation

- Deep, friable loam and alluvial soils with adequate organic matter, proper drainage, and the ability to hold moisture are the ideal soil types for growing onions successfully.
- Its growth requires temperatures between 21-26°C.
- Spacing: Use a 7.5 cm space between plants and a 15 cm between rows when transplanting—plant seeds between 1 and 2 cm deep.

Health benefits

- White onions include nutrients like chromium and sulfur that control and reduce blood sugar levels.
- Sulfur compounds and flavonoid antioxidants found in white onions have anticancer effects. Fisetin and quercetin, flavonoid antioxidants found in onions, may inhibit the growth of tumours.
- Packed with fiber and prebiotics, white onions feed the gut bacteria and uplift digestive health.
- White onions imbued with chromium, quercetin and sulfur help to control blood sugar spikes.
- White onions have anti-inflammatory, triglyceride-lowering, cholesterol-lowering, and antioxidant properties that benefit heart health.
- White onion is known to work as a natural blood thinning agent. The goodness of flavonoids and sulfur compounds helps in thinning of the blood,
- White onion juice is a well-known natural cure for hair loss, dandruff, and early hair ageing.

Summer vegetables: Common growing tips

Whichever summer vegetable you choose to grow, following are some growing tips you should keep in mind.

Grow regionally

Make sure to pick summer vegetables that will thrive in your area. If the growing season is shorter, select those vegetables that mature faster. Don't forget to choose heat-tolerant veggies for hotter climates.

Watering

Carefully irrigate plants every morning to reduce the rate of evaporation and avoid foliar diseases. Opt for drip irrigation to conserve water and reduce diseases caused by overhead watering.

Mulch

Spread a one- to two-inch layer of compost around your plants to conserve water, cool soil temperatures, and suppress weeds.

Provide shade

Summer vegetables like beets, broccoli, peas, greens, and cauliflower benefit from partial shade, particularly during a day's hottest part in warmer climates. Make sure to plant the veggies in a site that receives protection from the hot afternoon sun.

Plant successively

Re-sow summer vegetables like beets, bush beans, and lettuce every couple of weeks all through the summers to ensure continuous harvest.

Harvest:

Pick the summer vegetables either late or early in the day to keep the fresh, crisp, and flavourful.

Tips for Disease management

- Removing the diseased plant parts to stop the disease's transmission to other plants
- Allow adequate space between plants to reduce crowding and enhance air circulation. After the plants have been harvested, plough the soil to expose any diseased eggs to the sun.
- In the summer, cover the soil with transparent polythene to keep it warm and prevent the
- spread of weed seeds and diseases that are transmitted via the ground (Soil solarization process)
- Ensure that vegetable plants access enough water, nutrients, and sunshine.
- Water should not be applied to the surface of leaves or foliage because diseases thrive in moist plant parts.

- Summer vegetables should be picked at the proper time. Don't let them become overripe.

Conclusion

Many vegetables thrive in the summer, and summer veggies bring flavour and diversity to our unique summer meals. Furthermore, a variety of health benefits are typically associated with vegetables. They raise our energy levels and improve our immune system. In addition, all vegetables help us keep in shape as the seasons change. They strengthen our immune systems and provide us more energy. All vegetables also assist us in maintaining our fitness levels throughout the seasons.

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NURTURING ORGANIC FARMING AND LIVESTOCK SECTORS: A SUSTAINABLE APPROACH

Article ID: AG-VO4-I04-02

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Introduction

In recent years, there has been a notable surge in the demand for organic produce and ethically raised livestock. As consumers become increasingly conscious of the environmental and health implications of their food choices, the allure of organic farming and responsibly managed livestock is becoming more pronounced. To meet this growing demand and foster sustainable agriculture, it is imperative to explore strategies for nurturing both the organic farming and livestock sectors.

Embracing Organic Farming

1. Transition Assistance Programs

Governments and agricultural organizations can provide support to conventional farmers interested in transitioning to organic practices. This assistance can include financial incentives, technical guidance, and access to markets for organic produce.

2. Education and Training

Educating farmers about the principles and practices of organic farming is crucial. Workshops, training sessions, and extension programs can equip farmers with the knowledge and skills needed to adopt organic methods effectively.

3. Promotion of Soil Health

Organic farming revolves around maintaining soil health through practices such as crop rotation, composting, and minimal tillage. Encouraging these methods not only improves soil fertility but also enhances the resilience of agricultural ecosystems.

4. Certifications and Standards

Establishing clear certification standards and ensuring their enforcement is vital for maintaining consumer trust in organic products. Governments and certifying bodies must work together to uphold rigorous standards for organic farming practices.

5. Market Development

Developing robust market channels for organic produce is essential for the success of organic farming. This involves creating platforms for farmers to connect directly with consumers, as well as facilitating access to retail outlets and online marketplaces.

Fostering Sustainable Livestock Production

1. Grass-fed and Pasture-raised system

Encouraging the adoption of grass-fed and pasture-raised systems for livestock rearing promotes animal welfare and reduces the environmental footprint of meat production. Providing incentives for transitioning to these systems can drive positive change in the livestock sector.

2. Reducing dependency on Antibiotics

Overuse of antibiotics in livestock farming contributes to the proliferation of antibiotic-resistant bacteria. Promoting alternative methods for disease prevention, such as improved hygiene practices and vaccination, can help reduce reliance on antibiotics.

3. Support for small-scale Producer

Small-scale and family-owned farms often employ more sustainable practices compared to large-scale industrial operations. Providing support to these producers through grants, technical assistance, and marketing initiatives can bolster the sustainability of the livestock sector.

4. Integration of Livestock with Crop Farming

Implementing integrated crop-livestock systems can enhance resource efficiency and nutrient cycling on farms. By allowing livestock to graze on cover crops or crop residues, farmers can reduce the need for external inputs while improving soil health.

5. Consumer Education

Educating consumers about the benefits of ethically raised livestock products can stimulate demand for sustainably sourced meat, dairy, and eggs. Labels such as "grass-fed," "pasture-raised," and "certified humane" can help consumers make informed choices at the grocery store.

Conclusion

Nurturing organic farming and livestock sectors requires a multifaceted approach that addresses the needs of farmers, consumers, and the environment. By providing support for organic transition, promoting sustainable livestock practices, and fostering consumer awareness, we can create a more resilient and environmentally friendly food system. References to studies and research findings underscore the importance and efficacy of these strategies in promoting sustainability within the agricultural sector. Through collective action and commitment, we can cultivate a future where organic farming and responsible livestock production thrive hand in hand, ensuring the well-being of both people and the planet.

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BIOCHAR REVOLUTION: TRANSFORMING INDIAN AGRICULTURE FOR SUSTAINABILITY

Article ID: AG-VO4-I04-03

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Introduction

In the face of mounting environmental challenges and the need for sustainable agricultural practices, biochar emerges as a promising solution for enhancing soil health, improving crop productivity, and mitigating climate change impacts. In India, where agriculture is the backbone of the economy and faces numerous challenges, the utilization of biochar holds immense potential to transform farming practices and promote resilience in the face of climate variability. In this article, we delve into the use of biochar in Indian agriculture, exploring its benefits, applications, and implications for sustainable soil management.

Enhanced Soil Fertility and Nutrient Retention

Biochar, a charcoal-like material produced from organic waste through pyrolysis, acts as a stable carbon sink in soil, enhancing fertility and nutrient retention. In Indian agriculture, where soil degradation and nutrient depletion are significant challenges, the incorporation of biochar improves soil structure, increases water retention capacity, and promotes nutrient cycling, thereby enhancing crop yields and resilience to drought and nutrient stress.

Carbon Sequestration and Climate Mitigation

The incorporation of biochar into agricultural soils facilitates long-term carbon sequestration, mitigating greenhouse gas emissions and contributing to climate change adaptation and mitigation efforts.

In India, where the agricultural sector is a significant contributor to greenhouse gas emissions, the widespread adoption of biochar holds promise for achieving climate-smart agriculture goals while enhancing soil productivity and ecosystem resilience.

Soil Amendment and Remediation

Biochar serves as a versatile soil amendment, capable of improving soil pH, reducing soil acidity, and immobilizing toxic metals and pollutants through adsorption and ion exchange processes. In regions of India affected by soil salinity, alkalinity, or contamination, the application of biochar offers a cost-effective and environmentally sustainable solution for soil remediation and rehabilitation, restoring soil health and productivity.

Water Management and Conservation

Biochar-amended soils exhibit enhanced water retention capacity and reduced runoff, thereby mitigating soil erosion, improving water infiltration, and promoting drought resilience in rainfed agriculture.

In water-stressed regions of India, where erratic rainfall patterns and water scarcity pose significant challenges to agricultural productivity, the integration of biochar into soil management practices offers a strategic approach to enhancing water use efficiency and sustaining agricultural livelihoods.

Smallholder Adoption and Livelihood Improvement

The adoption of biochar technology presents opportunities for smallholder farmers in India to improve soil fertility, increase crop yields, and diversify income sources through the production and utilization of biochar-based products.

By promoting decentralized biochar production units and capacity-building initiatives, policymakers and development agencies can empower smallholder farmers to harness the potential of biochar technology, fostering rural development, and livelihood improvement across diverse agroecological regions.

Conclusion

Hence the utilization of biochar in Indian agriculture represents a paradigm shift towards sustainable soil management practices, climate resilience, and rural livelihood improvement. By harnessing the multifaceted benefits of biochar, from enhancing soil fertility and carbon sequestration to mitigating climate change impacts and promoting water conservation, India can chart a path towards a more sustainable and resilient agricultural future. Through collaborative research, policy support, and stakeholder engagement, the widespread adoption of biochar technology can catalyze transformative change in Indian agriculture, ensuring food security, environmental sustainability, and socio-economic prosperity for generations to come.

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ETHANOL THE ALTERNATIVE FUEL FOR BHARAT AND CREATE BOOM IN AGRICULTURE SECTOR

Article ID: AG-VO4-I04-04

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Introduction

Bharat's energy consumption is increasing day by day due to expanding economy, a growing population, urbanization, advancements in lifestyles, and increased spending power. Currently, Bharat imports 85% of its oil requirements. Domestic biofuels present a strategic opportunity for the government since they minimize reliance on imported fossil fuels. Under the Ethanol Blended Petrol (EBP) Program, the game-changing National Policy on Biofuels-2018 sets an approximate objective of 20% ethanol blending under the Ethanol Blended Petrol (EBP) Programme by 2030. The current average amount of ethanol blending in the country is 5% (2019-20). The Ministry of Petroleum plans to attain 10% ethanol blending levels in the Ethanol Supply Year (ESY) - 2021-22, which begins in April 2022, as a result of multiple initiatives on the ethanol supply side. This step along with achieving E20 targets around Bharat.

What is ethanol?

Ethanol (commonly known as ethyl alcohol or alcohol) is an organic molecule having the chemical formula C2H5OH. Ethanol is used in the portable sector, as well as the chemical and pharmaceutical industries. Ethanol demand is primarily influenced by blending rules, fuel availability, compatible vehicles, and infrastructure requirements.

Production: It can be made by fermenting sugars with yeast, a process similar to that used to make alcohol. It can also be generated chemically, for as via hydration of ethylene.

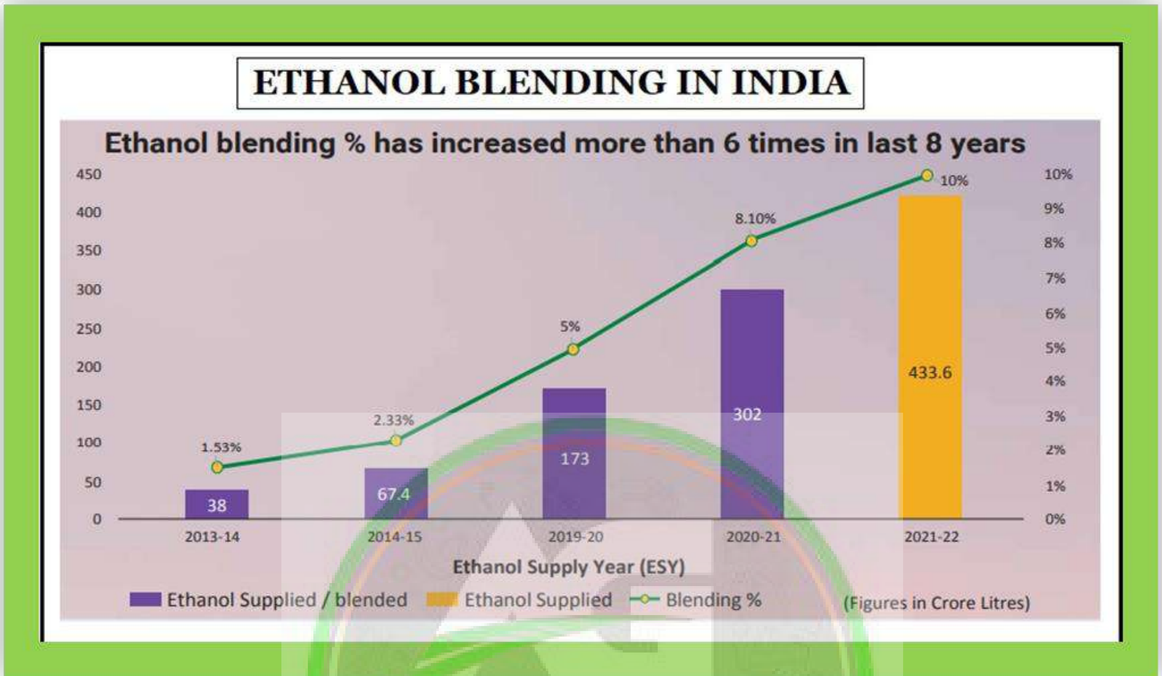
What is the Ethanol Blending Program (EBP)?

- The EBP is a project launched by the Bharat government to promote the use of ethanol, a renewable and environmentally beneficial fuel, in petrol. The program intends to reduce fuel imports from other nations, conserve foreign exchange, and boost value addition in the sugar business.
- Ethanol is mostly made from molasses, a byproduct of the sugar industry; however, additional raw materials such as sugarcane juice, sugar, sugar syrup, and damaged food grains can be employed.
- Because to effective government initiatives, ethanol supply to OMCs grew by more than 13 times in ESY 2022-23 compared to ESY 2013-14.
- The blending percentage has also risen from 1.53% in ESY 2013-14 to the objective of 12% in ESY 2022-23.
- The aim of 10% ethanol blending established in the 'Roadmap for Ethanol Blending in India 2020-25' for Ethanol Supply Year (ESY) 2021-22 has already been met, and Public Sector Oil Marketing Companies (OMCs) have begun selling E20 (20% ethanol blended) petrol across the country. Furthermore, the National Policy on Biofuels - 2018 aims to blend 20% ethanol into petrol by ESY 2025-26.

Significance of ethanol blending in fuels:

1. Reducing Fossil Fuel Dependence: Bharat imports the majority of its oil, leaving it exposed to global market volatility and geopolitical threats. Using ethanol, India can reduce its reliance on oil imports while increasing its energy independence.
2. According to a study conducted by the Indian Institute of Science in Bangalore, mixing ethanol with petrol can lower carbon monoxide emissions by 30-50% and hydrocarbon

emissions by 20%.). Results Bharat can enhance its air quality while also meeting its climate targets.



3. Farmer Support: Agricultural inputs such as sugarcane or corn are required for ethanol manufacturing. By employing ethanol, India can generate new demand for these crops, increasing farmer and rural community income and livelihoods.
4. Improving Energy Security: Ethanol is a domestic and diverse source of energy that can help India lessen its reliance on a single, foreign source of energy. By adopting ethanol, Bharat can improve its energy security and resilience.
5. Economic Benefits: Ethanol blending can boost the expansion of the ethanol industry, resulting in additional jobs, investments, and innovations. It can also help India build a more sustainable and modern energy infrastructure.
6. They may boost employment, Make in India, Swachh Bharat, double farmers' incomes, and turn waste into wealth.
7. To give a boost to the agriculture sector and to reduce environmental pollution.

NODAL AGENCY FOR ETHANOL PRODUCTION:

The Department of Food and Public Distribution (DFPD) is in charge of promoting the country's fuel grade ethanol distilleries. The government has approved ethanol production/procurement from sugarcane-based raw materials such as C & B heavy molasses, sugarcane juice / sugar / sugar syrup, leftover rice with Food Corporation of India (FCI), and maize. The recent authorization of the National Agricultural Cooperative Marketing Federation of India (NAFED) and the National Cooperative Consumers' Federation of India (NCCF) to procure maize (corn) for supplying ethanol distilleries emphasizes this transition and will help to establish an organized maize-feed supply chain for ethanol production. The raw material conversion efficiency is tabulated below.

Feedstock cost and ethanol yield

Feedstock	Cost / MT of the feedstock (Rs.)	Quantity of ethanol per MT of feedstock	Ex-mill Ethanol Price (Rs./litre)
Sugarcane juice / Sugar / Sugar syrup	2850 (Price of sugarcane at 10% sugar recovery)	70 litre per ton of sugarcane	62.65
B Molasses	13,500	300 litre	57.61
C Molasses	7123	225 litre	45.69
Damaged Food Grains (Broken Rice)	16,000	400 litre	51.55
Rice available with FCI	20,000	450 litre	56.87
Maize	15,000	380 litre	51.55

#The rates vary from region to region and also in accordance with demand/supply or quality.

Limitations of Water Intensity for Ethanol Production:

1. To achieve the 2025 aim of E20 Ethanol Blending in fuel, a study was done to identify prospective sources of ethanol production based on water use.
2. Sugarcane is a highly water-intensive crop. A tonne of sugarcane yields 100 kg of sugar and 70 Liters of ethanol. Sugarcane cultivation takes 1600-2100 Liters of water per kg of sugar. As a result, 3000 Liters of water are required to produce one litre of sugar-based

ethanol. Sugarcane and paddy use over 70% of the country's irrigation water. To conserve water, consider shifting some sugarcane areas to less water-intensive crops by offering incentives to growers.

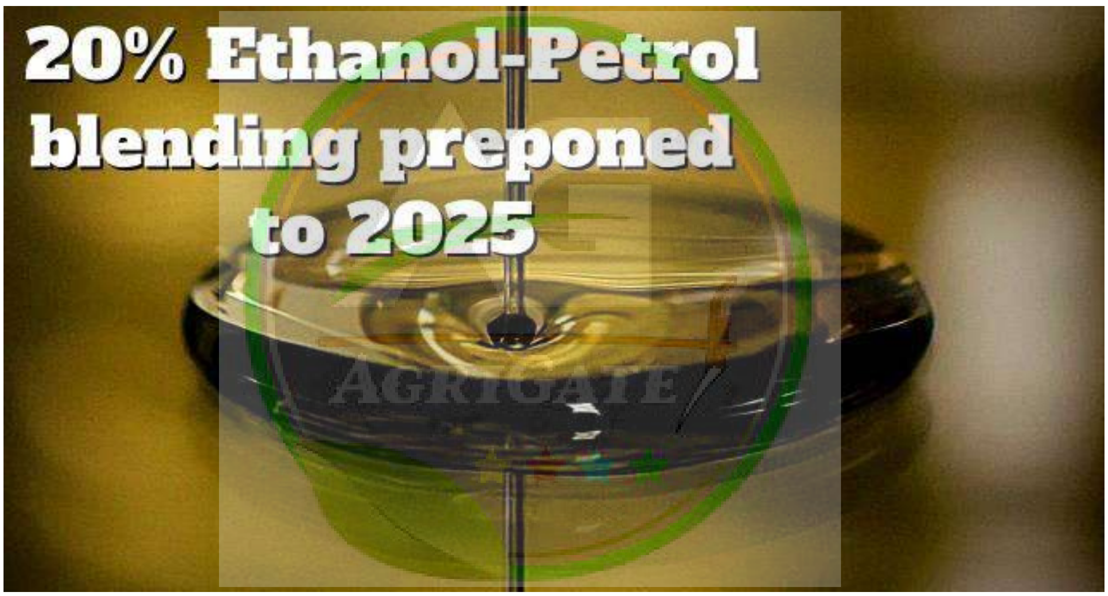
Encouraging use of water saving crops to produce ethanol:

1. Based on the preceding research, Sweet sorghum has significant benefits over sugarcane, rice and maize as a feedstock for biofuel production. It uses only half the water needed to grow maize and one-eighth the water needed to cultivate sugarcane. According to ICRISAT sources, sweet sorghum has a production cost that is only one-fifth that of sugarcane.
2. Maize is the least water-intensive crop for producing ethanol after sweet sorghum. To full fill the 2025 targets for ethanol production to encourage the **water saving crops**

Steps taken by the government to increase ethanol blending

1. To promote public awareness and education, create campaigns. Educate consumers on the benefits of ethanol blending, clarify myths about its effects on automobiles, and promote its use.
2. Transparency and Labelling: Make sure that ethanol blended fuels are clearly labelled at gas stations so that customers may make an informed choice.
3. Tax relief: E10 and E20 blends are taxed less than unblended petrol, making them more cost-competitive for customers. In comparison to petrol, ethanol has lower excise duty and GST rates.

4. Interest Subvention Scheme: In order to increase the country's ethanol production capacity and meet the blending targets established by the EBP Programme, the government has announced a number of ethanol interest subvention schemes ranging from July 2018 to April 2022. Under these ethanol interest subsidy schemes, the government is assisting entrepreneurs in establishing new distilleries (molasses-based, grain-based, and dual-feed based) around the country. The Central Government would bear an interest subvention of 6% per year or 50% of the rate of interest charged by banks/financial institutions, whichever is lower, on loans to be given by banks/financial institutions for five years, including a one-year moratorium.



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ROASTING EXCELLENCE: ADVANCING COFFEE QUALITY WITH INTEGRATED PEST MANAGEMENT

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Abstract

Coffee (*Coffea* sp.) is one of the most significant agricultural commodities for the nation and a commodity with significant economic significance. Coffee crops are attacked by several pests, much like any other high-value commodity, and controlling these pests is essential to productive production. In order to maintain the population level of the pest below the level of damage in a way that is economically, environmentally, and ecologically viable, integrated pest management, or IPM, integrates the environment and population dynamics of the pest, takes into account the use of all available plant protection methods, and integrates appropriate measures. This literature review's objective was to compile data on studies pertaining to integrated pest management in the coffee crop.

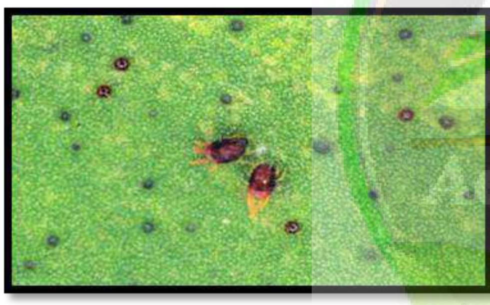
Keywords: Coffee, Integrated pest management, Insect pests, IPM.

Introduction

Coffee pests exhibit behaviours that are controlled by environmental elements found in their natural habitat, including temperature, microclimate, food availability, and the presence of natural adversaries. Modifying these regulatory elements results in unstable equilibrium and abrupt shifts in the ecosystem's population. Brazil is the second-biggest consumer of this commodity after Brazil, which is the major producer and exporter of it. One of the primary causes of the main crops' lower productivity is the harm that insect pests inflict. According to the most recent data, Brazil's agricultural production is lost by insect pests on average by 7.7% year, which equates to a loss of about 25 million tons of food, fibre and biofuels.

Integrated Pest Management

Like any other agricultural product, coffee plants are susceptible to a number of biotic and/or abiotic illnesses. Within the category of biotics, pest insects are particularly noteworthy, as they are inextricably linked to the environmental factors that affect plants, including temperature, microclimate, and food supply, and the existence of natural enemies.



Oligonychus ilicis

Hypothenemus hampei

Leucoptera coffeeella

We can single out the following pests as being of significant economic importance to the coffee industry: the Red Mite *Oligonychus ilicis* (Acari: Tetranychidae), the Coffee Bean Borer *Hypothenemus hampei* (Coleoptera: Curculionidae), and the Bicho-miner *Leucoptera coffeeella*

(Lepidoptera: Lyonetiidae). The crop's success can be ensured by effectively managing these pests. To do that, one must employ Integrated Pest Management (IPM) in order to coexist peacefully with the disease, the environment, and humankind

1. Cultural control

Manufacture of seedlings in climate-controlled nurseries; planting of healthy, hand-picked seedlings; application of living barriers; use of food-attractive traps and/or pheromone-based monitoring and control systems; sensible control of spontaneous plants; removal of infected cultural remnants; application of mulches; appropriate production conditions, periods, and locations; utilization of less soluble fertilizer formulations; The techniques include managing the residual organic matter, using crop rotation principles, fallow areas for the planting of fresh coffee crops, composting organic waste, and applying green manure.

Pheromone trap

2. Biological Control

The natural phenomena known as "biological control" refers to how biotic agents of mortality, or natural enemies, control the population of plants and animals. It involves the reciprocal density mechanism, which functions by constantly regulating one population by another; in other words, a living thing is constantly taken advantage of by another living thing and has reflexes to sustain population increase, so preserving the natural equilibrium. Conservation and use of natural control agents' potential, i.e., bacteria, fungi, parasitoids, and predators; mass release of these agents in the cultivation environment; cultural management; appropriate application of selective pesticides (conservative).

3. Chemical Control

Accurately identifying pests and the network of natural enemies that oppose them; keeping an eye on pests and using pesticides with various chemical groups and modes of action in a sensible and targeted manner; use of pesticides that are registered with federal agencies for the crop or pest and with state agencies that are competent; advice provided by agronomic prescription; use of personal protective equipment; proper application of pesticide application technologies; limitation of insecticide and acaricide use to preventive applications and their wide range of action.

Conclusion

In brief, integrated pest management (IPM) comprises a range of techniques aimed at lowering the prevalence of pests in a certain crop. It is a collection of actions used to prevent pests from harming the crop economically to a sufficient degree. Social, ecological, and economic factors form the basis of the IPM. A cost/benefit analysis is carried out for this. This strives for sustained production and maximizes the advantageous effects of natural enemies.

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PARTICIPATION OF BIOHERBICIDES IN WEED MANAGEMENT AND THEIR MODE OF ACTION

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Abstract

By employing bioherbicides, it enhanced crop productivity, removal of undesired plants and control of weeds in effective and cost-efficient manner while being environmentally benign. Target-specific mycoherbicides kill only the chosen weeds and do no harm to unintended plants. *Phytophthora palmivora* (Devine) and *Collectotrichum gleosporiodes* (Collego) like few bio herbicides that are readily available on a commercial basis. The major barriers of the development of bioherbicides are virulence of infections of pathogens and environmental requirements.

Key words: Mycoherbicide, Virulence, Eco friendly.

Introduction

For more than 70 years, the synthetic herbicides were used to control the weeds in developed nations. The increasing development of resistance to commercial herbicides and even non-target site mechanisms of resistance to herbicides that have not yet been developed is a sign of the ageing of this technology (Gaines *et al*., 2020). Few herbicides are being released that have new chemical classes, new molecular targets, or neither, and for which there is no resistance (Qu *et al*., 2021). Insecticides and fungicides with novel molecular targets have been inspired by natural compounds, but herbicides have been inspired by them to a significantly lesser degree (Lorsbach *et al*., 2019). As glyphosate took up the herbicide business and drastically decreased its total worth, there may have been a relative decrease in the effort put into herbicide innovation. Similar trends have not been observed in the insecticide and fungicide sectors. In spite of this, data about the molecular targets of numerous natural phytotoxins suggests that natural products may serve as the foundation for novel herbicides, which would aid in addressing the issue of herbicide resistance (Duke *et al*., 2022).

Strategies of biological control of weeds

- **Inoculative or classical approach** - control of invasive weeds by introducing non native control organisms from the weed's natural habitat.
- **Augmentative or inundative** - pathogenic organisms are already present (native or introduced) - population is increased by mass rearing.

Formulation of Bioherbicides

The development of unique formulations is necessary to ensure the activity of the agent once it is delivered in the field because many foliar and stem fungal diseases are temperature- and humidity-sensitive. Boyetchko *et al*. (1998) listed the requirements for bioherbicide formulation technology that must be met in order to preserve or improve the biocontrol agent's efficacy and be compatible with traditional field application technologies. Various emulsions, hydrophilic polymers, organosilicone surfactants, and granules encapsulated in alginate, starch, or cellulose are the primary formulation types currently in use. Each of these formulation types has benefits and drawbacks when it comes to enhancing the virulence, effectiveness, and ease of application of the biotic agents (Hallett, 2005).

Effect of plant based and Microbial bioherbicides on weed control

Water-soluble organic acids, alcohols, aldehydes, ketones, lactones, fatty acids, polyacetylenes, quinones, phenolics, cinnamic acid, coumarins, flavonoids, tannins, terpenoids, and steroids are among the many metabolites secreted by plants that inhibit weed seed germination and growth, inhibit cellular respiration, increase electrolytic leakage, membrane disruption, chlorosis, necrosis, and wilt, metaxylem cell division in roots, amylase activity, total soluble sugar, CAT, POX, POL, and SOD, while increasing starch, polyphenols, glutathione, and ascorbate, inhibit weed seed germination, increase lipid peroxidation, H2O2, CAT, and decrease

SOD (Mutlu *et al*., 2011). Plant-based bioherbicides may therefore be a natural way to manage weed populations. A variety of plant extracts and microbial bioherbicides have been used to prevent the growth of weeds (Fig. 1).

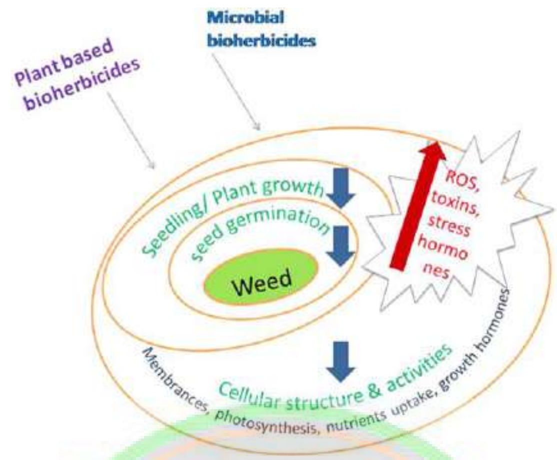

Fig.1. Effect of plant based and Microbial bioherbicides on weed control (source: Radhakrishnan *et al*., 2018).

Status of Bio herbicide and Formulation

A number of carefully chosen microorganisms have either undergone intensive development and evaluation, or are currently being produced for commercial use. Table 1 displays the formulation types and a more thorough efficacy of the bioherbicide against the target weeds.

Table 1. Commercial bioherbicide and formulations (Source: Roberts *et al*., 2022)

S. No.	**Target weed**	**Biocontrol agent**	**Product name**	**Formulation type**	**Year of registration and country**
1.	Persimmon (*Diospyros virginiana*) trees in rangelands	*Acremonium diospyri*	*Acremonium diospyri*	Conidial suspension	1960 Canada
2.	Dodder (*Cuscuta chinensis* and *C. australis*) in soybeans	*Colletotrichum gloeosporioides f. sp. cuscutae*	Lubao	Conidial suspension	1963 China

3.	Milkweed vine (*Morrenia odorata*)	*Phytophthora palmivora* (*P. citrophthora*)	DeVineR	Liquid spores suspension	1981 USA
4.	Northern joint vetch (*Aeschynomene virginica*)	*Colletotrichum gloeosporioides* f. sp. *aeschynomene*	Collego ™ (Lockdown R)	Wettable powder	1982 USA
5.	Sickle-pod and coffee senna (*Cassia* spp.)	*Alternaria cassiae*	Casst ™	Solid	1983 USA
6.	Water hyacinth (*Eichhornia crassipes*)	*Cercospora rodmanii*	ABG-5003	Wettable powder	1984 USA
7.	Yellow nutsedge (*Cyperus esculentus*)	*Puccinia canaliculated*	Dr. Biosedge®	Emulsified suspension	1987 USA
8.	Velvet leaf (*Abutilon theophrastus*)	*Colletotrichum coccodes*	VelgoR	Wettable powder	1987 Canada
9.	Round-leaved mallow (*Malva pusilla*)	*Colletotrichum gloeosporioides* f. sp. *malvae*	BioMalR	wettable powder in silica gel	1992 Canada
10.	Turf grass (Poa annua) in golf courses	*Acacia* sp. *Cylindrobasidium leave*	Stumpout ™	Liquid (oil) suspension	1997 South Africa
11.	Woody plants blackberry weed (*Prunus serotina*)	*Chondrostereum purpureum*	BioChon ™	Mycelial suspension in water	1997 Netherlands
12.	Turfgrass (Poa annua) in Golf	*Xanthomonas campestris* pv.	Camperico ™	Bacterial strain cell	1997 Japan

	courses	*poae*		suspension	
13.	*Hakea gummosis* and *H. sericea* in native vegetation	*Colletotrichum acutatum*	Hakatak®	Conidial suspension	1999 South Africa
14.	Dyer's woad (*Isatis tinctoria*) in farms, rangeland, waste areas and roadsides	*Puccinia thlaspeos*	Woad Warrior	Powder	2002 USA
15.	Deciduous tree spp.	*Chondrostereum purpureum*	MycoTech ™ paste	Paste	2002/2005 Canada
16.	Alder, aspen and other hardwoods	*Chondrostereum purpureum*	Chontrol ™ (EcoClear ™)	Spray emulsion and paste	2004/2007 Canada
17.	Dodder species	*Alternaria destruens*	SmolderR	Conidial suspension	2005 USA
18.	Dandelion (*Taraxacum officinale*) in lawns/turf	*Sclerotinia minor*	Sarritor	Granular	2007 Canada
19.	*Striga hermonthica* and *S. asiatica*	*Fusarium oxysporum* f sp. *stigae*	Striga	Solid dried chlamydospores + Arabic gum	2008 Africa
20.	Soda apple (*Solanum viarum*)	Tobacco mild green mosaic Tobamovirus (TMGMV)	SolviNix ™	Wettable powder/Foliar spray suspension	2009 Florida, USA

21.	Broadleaved weeds	*Lactobacillus* spp. + *Lactococcus* spp.	Organo-sol	Liquid	2010 Canada
22.	Broadleaved weeds	*Phoma macrostoma*	Formulation product name not specified	Granules composed of mycelial fragments and flour	2011 Canada/USA
23.	Broadleaved weeds	*Streptomyces* spp.	MBI-005	EP Killed, non viable *S. acidiscabies* strains RL-110T	2012 USA/Japan
24.	Horse purslane (*Trianthema portulacastrum*) in agricultural crops	*Gibbago trianthemae*	Gibbatrianth	Conidial suspension	2014 India

Conclusion

By eliminating or drastically reducing the use of chemical herbicides, bioherbicides provide an environmentally friendly way to mitigate these negative effects while also lowering their harmful effects. A sustainable approach to weed control is provided by the selective and differential phytotoxicity of bioherbicides. Herbicidal residues have a negative impact on the environment and food production, but switching from chemical to biological weed control also lowers weed population densities.

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HEGEMONIC ORGANIC PRACTICES: SUCCESS STORIES OF ORGANIC FARMERS IN CHETPET, TIRUVANAMALAI DISTRICT IN TAMILNADU

Article ID: AG-VO4-I04-07

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Introduction

Conventional farming which involves the use of inorganic fertilizers, pesticides, and herbicides has led to many environmental problems like soil degradation, water pollution, and health risk of both animals and human beings. While organic farming involves the use of organic inputs that results in promoting the soil health, reduces the water pollution, maintain good health of human and animals and overall paves way for the ecological sustainability. This article will discuss about the success stories of organic farmers in Chetpet block, Tiruvannamalai district, Tamil Nadu.

Organic Sugarcane Growing farmer

Elango, a 40-years-old farmer in Thachaambadi village in Chetpet block cultivates sugarcane crop in organic way and produces organic brown sugar. He owns a land of 8 acre and currently cultivates sugarcane variety CO 86032 [mostly preferred for producing brown sugar]. In the year 2013, Elango attended the training programme of Subash Palekar [Indian Agriculturist, Natural farming] in Tiruvannamalai district where he got astonished by the concept of natural farming and the use of organic inputs like the organic manure, panchagavya, pathilai karaisal [the use of fermented 10 leaves] and he adopted the organic farming practices in his own farm. In the beginning of organic farming, he faced issues like low yield, high input cost but later he earned more profit in organic farming than in conventional farming. He is practising organic farming for almost 10 years and he uses organic compost, panchagavya, as fertilizers and uses pathilai karaisal, dry ginger for plant protection to control pest and diseases. He is now successfully cultivating the sugarcane crop and producing the organic brown sugar and sells it in nearby villages and transports to the retail shops in Chennai, Trichy and other districts. He also motivates the other farmers in his village to adopt organic farming.

Cultivation of Traditional Paddy Varieties by Organic methods

Pichandi, a 66-year-old farmer in kizhpattu village of chetpet block cultivates the traditional varieties of paddy by applying organic farming. He studied many organic farming books and also developed sense of creating poison less soil and food for the current and future generation. He adopted organic farming practices in the year 2012 and now practising it for about 11 years in his 12 acres of land and is primarily cultivating the traditional varieties of paddy like karuppu kavni, Mappillai Samba, kichili samba and he also cultivates groundnut, black gram. He uses enriched farmyard manure, fish extract, azospirillum, *Pseudomomas viride* as bio-fertilizers and pathilai karaisal as plant protection materials to control pest and disease. He incurred heavy losses at the starting period but now he succeeded and earns more than 20,000 of profit in organic farming than in conventional farming. He sells his produce directly to the consumers and currently he has more than 150 regular consumers who purchases his produce regularly. He is also conducting a number of training programs on organic farming along with the agricultural department and also attends the training programs all over Tamil Nadu.

Status of Organic Farming in Chetpet Block, Tiruvanamalai District

Chetpet is one among the 18 blocks of Tiruvannamalai district whose primary occupation is agriculture and mostly cultivates crops including paddy, groundnut, sugarcane, black gram and vegetable crops like tomato, brinjal, okra, chilli and fruit crops like banana, mango, guava and so on. Majority of the farmers in this block are conventional farmers and they use inorganic fertilizers, pesticides, herbicides in their farm to get higher yields and very few farmers are organic farmers in this block. Conventional farmers are not ready to adopt the organic farming due to some constraints in the beginning of adopting organic farming.

Constraints in Adopting Organic Farming

- Reduced returns during the transformation period
- High input cost
- Susceptible to pest and disease attacks
- Difficult certification process

- Difficulties in Marketing

Government Taken Initiatives to Promote Organic Farming

Conducting training program to give awareness about the about the importance of organic farming and advicing the farmers to use organic inputs like *Trichoderma viride*, *Pseudomonas flurosence*, etc.

Providing incentives to organic cultivation of vegetables like onion, greens, tomato, brinjal and also assist in organic certification under the scheme of National Agricultural Development Programme [NADP].

There are many schemes for promoting the organic farming and the agriculture department in chetpet block are focusing on increasing the number of organic farmers in their respective villages.

Conclusion

Organic farming is the best method of farming in terms of promoting the soil health, improving the biological activity in the soil, reducing the water pollution and maintaining the ecological balance. Farmers have started understanding the importance of organic farming but they are hesitant to adopt because of losses in early stages of conversion from conventional method of farming to organic farming. Hence, the government should focus on the constraints faced by the organic farming adopters and appropriate policy measures should be implemented to increase the area under organic farming.

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THE ORIGINS OF KEY PLANT PATHOGENS

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Abstract

The article explores fungal taxonomy by delving into the etymology of genus names, revealing their significance in describing fungal traits. It traces origins from Greek and Latin roots to New Latin, unveiling naming conventions based on morphology, habitat, or pathogenicity. Each name's derivation, from "Pythium" to " Pellicularia," is succinctly explained, linking linguistic elements to fungal characteristics. This linguistic journey offers profound insights into fungal biology, enriching our understanding of these organisms and their ecological roles.

Introduction

Embark on a linguistic journey through fungal taxonomy, where the origins of genus names reveal profound insights into fungal biology. From ancient Greek to modern Latin, each name carries a story, illuminating the diverse traits and ecological roles of fungi. Join us as we decode the hidden meanings behind these names, enriching our understanding of these vital organisms and their impact on ecosystems.

Oomycota

Pythium originates from the Ancient Greek word "pū́thō," meaning "to make rot," combined with the suffix "-ium." It belongs to a genus of fungi causing root-parasitic diseases and falls under the family Pythiaceae.

Phytophthora infestans derives from Greek "phyto" meaning "plant" and "phthora" meaning "decay, ruin, perish," with "infestans" from the Latin "infestare," signifying destroying."

Sclerospora's name comes from Greek "skleros," meaning "hard" or "tough," combined with "-spora" denoting "seed" or "spore." Hence, the genus produces hard oospores to endure unfavorable conditions.

Peronosclerospora's etymology includes "Peronos" from Greek "peron," meaning "boot" or "sandal," "Sclero-" from "skleros," and "Spora" from "spora." It may signify "boot-hard spore," reflecting the robustness of spores.

Albugo, derived from Latin "Albus" for "white" and the common suffix "-go," likely describes the white or pale appearance of the fungal structures on infected plant tissues.

Aphanomyces combines Greek "aphano-" meaning "invisible" or "hidden," with "-myces" from "mykēs" meaning "fungus" or "mushroom." This hints at the challenge of detecting these microscopic fungi without specialized equipment.

Zygomycota

"Rhizopus" combines Greek "rhizo-," from "rhiza" meaning "root," with "-pus," from Greek "pous" meaning "foot." It likely describes the root-like rhizoids produced by fungi in this genus. Rhizopus species, commonly found on decaying plant material, feature extensive mycelium anchored by rhizoids to the substrate.

Ascomycota

The name Fusarium comes from the Latin word fusus, which means "spindle." Fusarium oxysporum is a genus of filamentous fungi that can be found in soil and in association with plants. It is an anamorphic species that includes both pathogenic and nonpathogenic strains.

The genus Pyricularia is named after the pyriform (pear-shaped) shape of its conidia.

"Magna" is a Latin word meaning "great" or "large." "-porthe" likely comes from the Greek word "porthē", which means "destruction" or "ruin." This name may refer to the destructive nature of the fungi in this genus, which are known to cause various plant diseases by infecting and damaging plant tissues.

Helminthosporium is a genus of fungi, and its name comes from Greek roots. "Helminth" refers to worms, and "sporium" refers to spores. In this context, "helminthosporium" essentially means "worm-like spores."

The genus name "Bipolaris" was established by the mycologist Kálmán Kukkonen in 1972. It is derived from the Latin prefix "bi-" meaning "two" or "twice," and "polaris," which refers to "poles" or "opposite ends." The name reflects the bipolar germination of the spores in this genus.

The genus name "Cochliobolus" is derived from Greek roots. "Cochlio-" originates from "cochlea," meaning "spiral" or "helix," and "bolus" signifies "lump" or "mass." Ascospores of Cochliobolus are hyaline, filamentous, and spirally flexed within asci. Therefore, "Cochliobolus" may refer to the spiral or helical shape of the ascospores (sexual spores) produced by fungi in this genus.

The genus name "Acrocylindrium" is derived from Greek roots. "Acro-" means "top" or "tip," and "cylindrium" likely comes from "cylinder," referring to a cylindrical shape. Therefore, "Acrocylindrium" could be interpreted as "top cylindrical," possibly indicating the shape or structure of the fungus or its reproductive structures.

The genus name "Ustilaginoidea" combines "Ustilago," referring to a group of smut fungi, with "-oides," indicating similarity or resemblance. However, unlike Ustilago, which belongs to the Basidiomycota phylum, Ustilaginoidea falls under the Ascomycota phylum. This suggests that fungi in the genus "Ustilaginoidea" share similarities with those in the genus "Ustilago" despite belonging to different phyla.

The generic name Claviceps comes from the Latin words clava and -ceps. Clava means "club" and -ceps means "head", which refers to the fungus' club-shaped head.

The genus name "Ephelis" originates from the Greek word "ephelis," which means "spot" or "blotch." This term is often used in botanical and mycological contexts to describe discolorations or blemishes on plant tissue caused by pathogens.

The genus name "Trichoconis" comes from the Greek word "trichos," meaning "hair," and "konis," which refers to "dust." This likely describes the fine, hair-like structures or conidia produced by fungi in this genus.

The genus name "Alternaria" originates from Latin, specifically from "alternus," meaning "alternate" or "interchangeable." This likely alludes to the alternating pattern of conidial formation seen in fungi of this genus. In Alternaria species, conidia are produced in chains, with the formation of new conidia alternating with the formation of septa between them.

"Sclerotinia" and "Sclerotium" derive from Greek "skleros," meaning "hard." In mycology, "sclerotium" denotes a hardened mass of fungal hyphae serving as a survival structure.

Cercospora

The genus name "Cercospora" is derived from Greek. It comes from "kerkos," meaning "tail," and "spora," meaning "seed" or "spore." Therefore, "Cercospora" can be interpreted to mean "tail spore," which may refer to the characteristic shape or appearance of the spores produced by fungi in this genus. These spores often have a distinct elongated or tail-like shape.

Exserohilum

The genus name "Exserohilum" is derived from Latin and Greek roots. "Ex-" means "out of" or "from," while "sero" is related to "serere," meaning "to join" or "to connect." "Hilum" refers to a small scar on a seed. This likely refers to the characteristic horn-like shape of the conidia produced by fungi in this genus, which often emerge from the hilum of the conidium.

Colletotrichum

The word Colletotrichum comes from New Latin, where colleto- comes from the Greek word kollētos, which means "glued", and -trichum comes from the Greek word trich-, which means "hairs". Therefore, Colletotrichum referring to the production of black colour hair like seta in their asexual fruiting body, acervulus.

"Aspergillus" is Latin-derived, stemming from "aspergere," meaning "to sprinkle." Coined by Pier Antonio Micheli, it refers to the fungi's conidiophores resembling a sprinkler or brush, due to their outward radiating structure.

"Penicillium" originates from Latin "Penicillus," meaning "brush." The suffix "-ium" denotes a genus. Thus, "Penicillium" suggests a "brush-like" structure, referencing the conidiophores' resemblance to a paintbrush.

"Sphacelia" originates from Greek "Sphakelos," meaning "gangrene," and the suffix "-ia" denoting a condition. It likely reflects the parasitic fungus's ability to induce decay in plant tissue, resembling gangrene.

"Botryosphaeria" combines Greek "botrys," meaning "bunch of grapes," with "-ia." The name likely refers to grape bunch-like conidiophores produced by fungi in this genus.

"Mycosphaerella" blends Greek "Myco-" for "fungus" and Latin "Sphaerella" for "small sphere." This likely describes the small, spherical fruiting bodies or spore-bearing structures produced by fungi in this genus.

The genus name "Gloeosporium" is derived from Greek and Latin roots: "Gloeos" comes from the Greek word "gloios", which means "viscous" or "sticky." "-sporium" is derived from the Latin word "sporium," which means "spore" or "seed." This name likely refers to the appearance or characteristic of the spores produced by fungi in this genus, which may have a sticky or viscous texture.

The genus name "Verticillium" is derived from Latin roots: "Verticillus" means "little whirl" or "whorl" in Latin. The suffix "-ium" is commonly used in scientific names to form the names of genera. This name likely refers to the characteristic arrangement of the conidiophores, which form whorls or clusters, producing conidia in a distinctive pattern.

"Physalospora" originates from Greek "Physalos" for "bladder" and Latin "-spora" for "spore." It likely describes the bladder-like appearance of the fruiting bodies or spore-bearing structures produced by fungi in this genus.

"Myrothecium" originates from Greek "myron" for "ointment" and "-thecium" for "case." It likely describes the appearance of the fruiting bodies or spore-bearing structures produced by fungi in this genus, resembling small boxes or containers.

The genus name "Phyllosticta" is derived from Greek roots: "Phyllo-" comes from the Greek word "phyllo", which means "leaf." "-sticta" comes from the Greek word "stigme", which means "spot" or "mark." This name likely refers to the characteristic symptomatology of the diseases caused by fungi in this genus, which often manifest as spots or lesions on plant leaves.

The genus name "Septoria" is derived from Latin: "Sept" comes from the Latin word "septum," which means "partition" or "division." "-oria" is a suffix used in taxonomy. This name likely refers to the characteristic appearance of the fruiting structures (pycnidia) produced by fungi in this genus, which are often arranged in distinct compartments or divisions within the host tissue.

The genus name "Diaporthe" is derived from Greek roots: "Dia-" comes from the Greek word "dia," meaning "through" or "across." "-porthe" likely comes from the Greek word "porthē", which means "destruction" or "ruin." This name may refer to the destructive nature of the fungi in this genus, which are known to cause various plant diseases by infecting and damaging plant tissues.

The genus name "Ceratocystis" is derived from Greek roots: "Cerato-" comes from the Greek word "keras", meaning "horn" or "antler." "-cystis" comes from the Greek word "kystis", meaning "bladder" or "sac." This name likely refers to the appearance of the perithecium produced by fungi in this genus, which may resemble horned sac-like structures.

"Capnodium" stems from Latin "capnus," meaning "smoke," and the suffix "-dium." It likely alludes to the dark, smoky appearance of the spore-bearing structures (conidiomata) produced by fungi in this genus.

Basidiomycota

"Ganoderma" originates from Greek roots: "Gano-" from "ganos," meaning "brightness" or "sheen," and "-derma" from "derma," meaning "skin" or "covering." This likely describes the glossy surface of the fruiting bodies (conks) produced by fungi in this genus. Ganoderma species, known as "shelf fungi" or "polypores," often exhibit a shiny appearance resembling a sheen or brightness.

"Exobasidium" combines Greek "Exo-" for "outside" with Latin "-basidium" for "club," referring to the unique external basidia production on plant tissues, distinguishing it from typical basidiomycetes.

The genus name "Uromyces" is derived from Greek roots: "Uro-" comes from the Greek word "oura," meaning "tail." "Myces" is derived from the Greek word "mykēs," which means "fungus." This name likely refers to the characteristic appearance of the teliospores with tail-like stalks or appendages.

"Phakopsora" originates from Greek "phakos," meaning "lens," and the suffix "-sora." It refers to the appearance of the spore-bearing structures resembling small, lens-shaped formations on infected plant tissues.

"Melampsora" originates from Greek "melas," meaning "black," and the suffix "-psora." It likely denotes "black rust," referring to the dark-colored spore-bearing structures produced by fungi in this genus on infected plant tissues.

The genus name "Ustilago" is derived from the Latin word "ustilare," meaning "to burn." It is believed that this name was chosen due to the smut fungus' ability to cause blackened, burnt-like lesions on host plants.

"Sphacelotheca" combines Greek "Sphacelos," meaning "gangrene" or "mortification," with "-Theke," meaning "case" or "container." It likely describes the gall-like structures produced by fungi in this genus on infected plant tissues, reflecting the decay or death caused by the parasitic fungus.

The name Rhizoctonia means "root-killer" because the fungus named after it quickly kills plant roots. Rhizoctonia is a genus of fungi that causes root rot in various plants.

"Corticium" originates from Latin "cortex," meaning "bark" or "rind," and the suffix "-ium." It likely describes the habitat preference of fungi in this genus, often found growing on the bark or outer surface of trees and woody plants.

"Thanatephorus" originates from Greek "thanatos," meaning "death," and "-phoros," meaning "bearing" or "carrying." This likely denotes the pathogenic nature of fungi in this genus, causing diseases in plants that can lead to death.

The genus name "Crinipellis" is derived from Latin: "Crin-" likely comes from the Latin word "crinis," meaning "hair" or "tress." "-pellis" is a suffix used in Latin to denote a covering or skin. This name likely refers to the characteristic appearance of the fungal fruiting bodies (basidiocarps) produced by species in this genus, which often have a hairy or fibrillose surface.

"Oncobasidium" combines Greek "Onco-" for "mass" or "tumor" with Latin "-basidium" for "club," likely describing irregular basidia resembling a tumor or mass.

"Sphaerostilbe" combines Greek "sphaera," meaning "sphere" or "ball," with Latin "-stilbe," indicating "brightness" or "luster." This likely describes the appearance of the fungal structures in this genus, often spherical with a shiny or lustrous surface.

The genus name "Ustulina" is derived from Latin: "Ustulina" likely comes from the Latin word "ustulatus," which means "scorched" or "burnt." This name may refer to the dark, burnt appearance of the fruiting bodies (conks) produced by fungi in this genus, which are commonly found on fire-damaged or decaying wood.

The genus name "Marasmius" is derived from Greek: "Marasmius" is related to the Greek word "marasmos", which means "drying out" or "withering." This name may refer to the ability of some fungi in this genus to dehydrate and revive after periods of dryness, which is a characteristic feature of certain Marasmius species.

The genus name "Fomes" is derived from Latin: "Fomes" in Latin means "tinder" or "spunk," referring to a substance that ignites easily and sustains a fire. This name likely refers to the woody, often hoof-shaped fruiting bodies produced by fungi in this genus, which can be dry and easily ignitable, similar to tinder.

"Poria" is derived from the Greek word "poros," meaning "pore" or "passage," reflecting the porous nature of the fruiting bodies (conks) produced by fungi in this genus, often characterized by numerous small pores on their undersides for spore release.

"Armillaria" likely originates from Latin "armilla," meaning "bracelet" or "ring," possibly alluding to the ring-like structures (annuli) on the stems of some species' fruiting bodies.

"Pellicularia" originates from Latin "Pellicula" for "thin skin" or "membrane," likely describing the thin, membranous structures of fungi in this genus.

Conclusion

In summary, exploring the etymology of fungal genus names enriches our understanding of fungal biology and ecology. These linguistic insights offer valuable glimpses into fungal diversity and ecological roles. Moving forward, further research into fungal taxonomy promises to deepen our appreciation of these vital organisms and their complex interactions within ecosystems.

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CGIAR-RELATED CROP TECHNOLOGIES AND THEIR IMPACT ON AGRICULTURAL PRODUCTIVITY OF ASIAN COUNTRIES

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Abstract

Consultative Group on International Agricultural Research (CGIAR) is a consortium of International Agricultural Research Centers (IARC) which started their operations during 1960s. They are associated with major contributions to crop improvement in rice and wheat in Asia. In a recent economic impact analysis carried out by Fuglie and Echeverria (2024) which was published in the Journal "World development", the authors showed the diffusion and productivity impact of CGIAR crop research by crop, region, and over time. The data clearly revealed that modern varieties from all technology providers had spread to more than 450 million hectare in developing countries, while CGIAR-related crop technologies occupied about 221 million hectare, generating economic welfare gains of $47 billion annually during 2016–2020. It is well known that the impacts of "Green Revolution" were largely confined to rice and wheat in Asia. But recently, it can be realized in a wide range of crops and geographical regions, particularly cassava and maize in Sub-Saharan Africa. Among the various technologies, the development of improved crop varieties has been the prime technology of CGIAR crop centers which had a major share of impact in agricultural productivity in the developing countries. Other technologies such as CGIAR-related integrated pest management and natural resource management technologies have also made prominent contributions to crop productivity. The major objective of this popular article is to highlight the key findings of Fuglie and Echeverria (2024) in an abridged manner about the role of CGIAR-related research in achieving agricultural productivity in Asian countries.

Key words: Agricultural productivity, CGIAR, Developing countries, Economic impact

Introduction

CGIAR (formerly the Consultative Group for International Agricultural Research) is an international collaborative center that functions with major international organizations engaged in agricultural research, mainly in crop improvement and food security. It was constituted in 1971 by a group of donors to coordinate the financial support among partner centers, the first of which was established in 1960. Today the CGIAR system consists of 15 research centers engaged in agricultural research with a focus on the Global South and recently reorganized as One CGIAR. The research aims of CGIAR are to reduce rural poverty, increase food security, improve human health and nutrition, and sustainable management of natural resources. As a front runner of the "Green Revolution" in the 1960s, the international agricultural research centers are well recognized for achieving greater impacts on food crop productivity in developing countries (Anderson et al., 1988). Initially, it was driven to address an emerging Malthusian crisis i.e population growth versus food supply. However, the CGIAR later worked with a broader development goals (food, land, water and climate), emphasizing in particular the role of agricultural development in poverty alleviation in both rural and urban areas. Recent empirical studies have confirmed that at least in low-income countries, agricultural growth has had greater impact on poverty reduction than comparable rates of growth in non-farm sectors (Ivanic and Martin, 2018; Ligon and Sadoulet, 2018).

In this article, the term "CGIAR-related" technologies were used to refer to the innovations that can be substantially attributed to research conducted at CGIAR centers. Previously, many studies were made on the economic impact of the CGIAR on crop improvement. Evenson and Gollin (2003) found that modern varieties (MVs) of food crops evolved from CGIAR breeding programs had spread to about 170 million hectares in developing countries and had reduced global prices of food staples by 18–21 percent. To assess overall returns to donor investment in the CGIAR, Raitzer and Kelly (2008) included the benefits from 15 case studies of economic impacts from CGIAR research projects which included several crop breeding programs and found that benefits from just these projects exceeded total spending by the CGIAR. More recently, Alston et al. (2020) conducted a *meta*-analysis of 78 economic impact assessments of CGIAR-related research projects and concluded that on average, CGIAR research generated about $10 in benefits for every $1 in expenditures. In spite of the above facts, many developing countries have greatly risen their strength to conduct their own agricultural research and development over the past several decades (Pardey et al., 2016).

The purpose of this article is to bring out to the readers an updated data on the aggregate impacts of CGIAR crop improvement research, assess impacts by commodity and location from the economic impact analysis of Fuglie and Echeverria (2024). To better understand the role of the CGIAR to overall crop improvement in developing countries, Fuglie and Echeverria (2024) also reported the diffusion and impact of modern food crop varieties from all technology providers (including by the CGIAR, national agricultural research programs and the private sector).

Rationale for the study

Fuglie and Echeverria (2024) used a broader set of information on adoption of crop improvement technologies and combined this with plausible estimates of productivity impacts to provide a more comprehensive and granular economic impact assessment of CGIAR-related crop improvement research. When direct evidence on productivity effects is not available, they combined farm survey estimates of the rate of varietal turnover with empirical evidence from other studies on the average rate of yield gains in experimental plots and farmers' fields for different crops and production systems around the world.

They then used this evidence to derive plausible estimates of the impact of technology adoption on economic welfare. Because the findings are generated on country- and crop-specific information on technology adoption and diffusion, Fuglie and Echeverria (2024) were able to assess the economic impacts of modern varieties and CGIAR-related crop technologies over time, space, and for each of the 19 food crops included in CGIAR crop improvement programs. The accumulated impact over 1961–2020 of CGIAR-related crop technologies totalled at $1,334 billion (in 2015 US$), more than twice the benefits estimated by Alston et al. (2020), who used a framework similar to the authors but with less extensive adoption data. Gollin et al. (2021), on the other hand, used an econometric model that linked rates of national economic growth to when CGIAR-related MVs first became available to each country.

Diffusion of CGIAR-related crop technologies in developing countries

In this section, the key findings of economic impact study made by Fuglie and Echeverria (2024) are summarized below:

The first adoption of technologies from CGIAR centers occurred with improved rice and wheat varieties in Asia in the mid-1960s (Dalrymple, 1974). A key characteristic of these varieties was “semidwarf” stature in rice and wheat, which made them more responsive to chemical fertilizers. Rice MVs of first generation were also non-photo period sensitive and shorter duration. In areas with long or year-round growing seasons, these characteristics enabled farmers to increase their cropping intensity of rice and other crops grown in rotation. MVs of CGIAR wheat also had good resistance to rusts, a class of fungal diseases that can severely reduce crop yield.

With rapid technology dissemination for MVs of wheat, rice and other food crops, as well as dissemination of some IPM and NRM technologies, the total area accounted by CGIAR research reached nearly 221 million hectares by 2020. CGIAR-related MVs (those directly bred by CGIAR centers and varieties developed by other institutions using CGIAR germplasm as parent material) were sown on about 190 M ha, about 26 percent of the total harvested area of these crops in developing countries (Fig 1.). Other CGIAR-related crop technologies such as IPM and NRM had spread to another 30 M ha, some of which was also planted with improved varieties. CGIAR-related MVs accounted for about 43 percent of the total 447 M ha of the total area sown with MVs for these crops in developing countries, with the other 57 percent of modern varieties in use coming from national and private breeding programs with no obvious CGIAR contribution in their pedigrees.

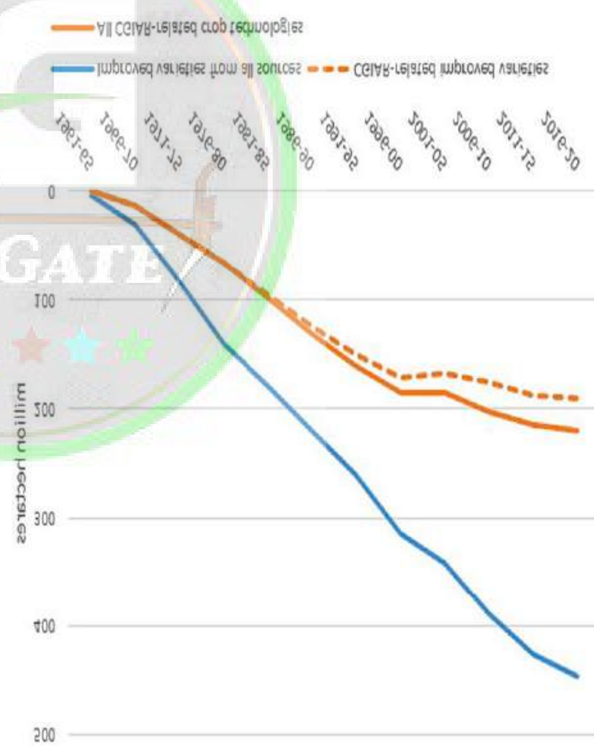

Fig. 1. Diffusion of Modern Varieties and CGIAR-related Crop Technologies in Developing Countries (Source: Fuglie and Echeverria, 2024)

The importance of the CGIAR to crop improvement varied widely across crops and regions. Overall, CGIAR-related MVs made up about 42 percent of the total MV area in developing countries. CGIAR-related MVs were particularly important for wheat (72 percent of all wheat area in MVs) and least important for pulses (9 percent) and sweet potato (6 percent overall but much higher if China is excluded). CGIAR-related varieties account for about 36 percent in Asia. In many countries, first generation MVs were replaced by new generations of varieties. These have provided additional gains to yield and yield stability, plus other traits like improved grain quality and early maturity. For example, in Asian rice production, second generation varieties like IR36 (released in 1976) offered improved resistance to pests and diseases than first generation varieties like IR8 (released in 1966) (Fischer and Cordova, 1998). Third generation varieties like IR64 (released in 1985) offered further improvements to yield and eating quality (Mackill & Khush, 2018).

Diffusion of modern varieties and CGIAR-related crop technologies became more geographically dispersed over time. In the early years of the Green Revolution, adoption of improved technologies was dominated by Asia. By 2016–2020, Asia's share of the area affected by CGIAR-related crop technologies had declined to just over half.

Productivity and welfare impacts of technology adoption

Estimates of how the adoption of modern varieties likely to affect the productivity in specific crops and regions showed that the adoption of first generation MVs raised crop yield by 30–40 percent, with second and subsequent generation MVs increasing the yield a further 10–20 percent over the yield of traditional varieties (TV). In Asia, the average yield of rice prior to adoption of improved technologies averaged 1,891 kg/ha. Replacement of the first generation of modern varieties raised the net yield by 39.8 percent, or by 753 kg/ha. The second generation of improved rice varieties in Asia are assumed to have raised to an additional 14.3 percent over TV yield, or by 270 kg/ha. In Sub- Saharan Africa, TV yields of maize in Sub-Saharan Africa averaged 1,104 kg/ha, with first generation MVs raising base yield by 38.9 percent, or by 429 kg/ha. Though it is assumed that the productivity effects of CGIAR-related MVs are similar to those from MVs from other sources, CGIAR-related MVs had larger productivity impacts than non-CGIAR MVs at least prior to 2000 (Evenson, 2003).

During the first two decades of the new millennium, the CGIAR continued to contribute substantially to agricultural development across all countries in the globe. Aggregate impacts were still growing in the 2010s, adding about $600 million per year in economic surplus to developing countries. This was about the same pace of growth in economic welfare that they achieved in the 1990s, when annual benefits were growing at about $700 million per year. Fuglie and Echeverria (2024), based on their study, identified 92 developing countries where at least some impact of CGIAR-related crop technologies had occurred by 2020. They reported the adoption area and economic surplus by country-wise in 2016–2020, as well as the cumulative surplus generated from CGIAR-related crop technologies over 1961–2020.

The data indicated that India, China and Nigeria have been the largest beneficiaries of CGIAR-related crop technologies. In India, the cumulative economic surplus generated from adopting CGIAR-related crop technologies over 1961–2020 was $334 billion, and was providing about $10.2 billion/year in economic surplus in 2016–2020. China's aggregate benefits were $231 billion, although in recent years annual benefits declined as technologies from other sources replaced CGIAR-related innovations. In Sub-Saharan Africa, Nigeria has been the largest beneficiary of CGIAR-related crop technologies, receiving $148 billion over 1961–2020 and $9.3 billion/year in 2016–2020. In Latin America, Argentina has been the largest beneficiary, earning $42.5 billion over 1961–2020 and $1.9 billion/year in benefits during 2016–2020. Several of these beneficiary countries have graduated to upper middle-income status since the CGIAR centers were established in the 1960s. Furthermore, some of these countries have greatly expanded their own investments in agricultural research and development. However, the CGIAR continues to be funded almost entirely by high income countries, philanthropic foundations, and international development organizations (Alston et al., 2020). Widening the funding base to include more contributions from beneficiary countries could help stabilize and expand the system.

Conclusion

For the past six decades, CGIAR research centers have made profound contributions to improving agri-food systems in developing countries. Between the first release of improved varieties of wheat and rice in the mid-1960s, CGIAR-related crop technologies spread to about 221 million hectare by 2020. The above study presented the data on technology adoption which clearly reveal the factors such as which crops and technologies of CGIAR made an impact on agricultural development in the developing countries. In the 1970s and 1980s, wheat and rice in Asia contributed for a major chunk of the welfare benefits from CGIAR-related crop technologies. Pest management became an important complement to improved varieties in CGIAR efforts to increase crop productivity in developing countries. While Asian and Latin American countries became less dependent on the CGIAR as a source of improved crop varieties over a period of years, it should be emphasized that Sub-Saharan Africa continued to rely heavily on the CGIAR for innovations in crop production.

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UNDERUTILIZED POTENTIAL BEAN- DOLICHOS BEAN SPECIES AND TYPES

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Introduction

Dolichos bean, *Lablab purpureus* L. Sweet (2n = 22), belongs to family Fabaceae with 2n = 22 chromosomes . It is one of the most ancient crops among cultivated plants is largely cultivated across the tropical regions of Asia and Africa . In India it is mainly grown in the states of Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh and North Eastern states.

Taxonomic Tree

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Fabales
Family: Fabaceae
Genus: Lablab
Species: Lablab purpureus

Botanical varieties of dolichos are categorized into two types viz., *Lablab purpureous* var. *typicus* and *Lablab purpureus* var. *lignosus* with the former cultivated for its soft, edible pods and consumed as a vegetable whereas the later with dry seeds is largely used as a pulse food. *Dolichos* genus, often known as Hyacinth Bean, contains around 60 species of flowering plants native to tropical regions. These are usually climbing or twining plants with trifoliate leaves and pea-like flowers. Blooming is followed by ornamental seed pods in many species. Dolichos plants prefer to grow in full sunlight and require a soil with good drainage. They can be grown from seeds, which should be soaked before planting to aid germination. These vines need support to climb, and they can make a striking addition to fences, trellises, or archways. While some species of this genus produce edible beans, others may be toxic, and should be grown with caution.

(a) Dolichos lablab / *Lablab purpureus* (Hyacinth Bean)

The *Dolichos lablab* plant (also known as *Lablab purpureus*) is a climbing or trailing vine that can grow up to 20 feet (6 m) in height. It is notable for its beautiful dark purple flowers and glossy purple pods, giving it a unique appearance.

Dolichos lablab - Hyacinth bean

(b) *Dolichos trilobus* (Three-lobed Dolichos)

The *Dolichos trilobus* plant is a perennial vine. It can reach up to about 15 feet (4.5 m) in height. Three-lobed Dolichos is unique in its appearance, as it features trifoliate leaves and yellow flowers.

Dolichos trilobus (Lablab Bean / Three lobed Dolichos)

(c) Dolichos purpureus / Lablab purpureus (Purple Dolichos)

The *Dolichos purpureus*, now considerd a synomyn of *Dolichos lablab*, and reclassified as *Lablab purpureus*, is a species is a vining plant that grows up to ten feet (3 m) tall. It is marked by its distinctive, deep purple flowers and elongated, flat pods.

Its vibrant colors make it a popular choice for ornamental use in gardens. It should be planted in a sunny, well-drained area. Purple Dolichos blooms in the summer. It is cultivated for its edible pods in some parts of the world.

(d) Dolichos biflorus

Dolichos biflorus, now possibly classified as being in the *Macrotyloma* genus, can reach about 12 inches (30 cm) in height. It is a creeping annual herb with small, yellow flowers. Horse Gram has edible seeds, these are popular in Indian cuisine.

This plant is grown in gardens for culinary use. It is also a useful drought tolerant plant. Plants typically bloom in late summer to early autumn. It can grow in a variety of soils, so long as it is in a sunny location.(

(e) Dolichos lablab v alba Cultivar (White Hyacinth Bean)

The cultivar *Dolichos lablab 'Alba'* (*Lablab purpureus* 'Alba')is a striking climbing or trailing vine. It is able to reach a height of up to 20 feet (6 m). What sets White Hyacinth Bean apart from the parent species is its display of pure white flowers, and light green pods.

Dolichos lablab v alba Cultivar (White Hyacinth bean)

Often grown as an ornamental plant, its contrasting coloration is great for adding a unique visual appeal to gardens. Grow in a location that has full sun and well-drained soil conditions. In addition to its ornamental uses, it is also valued in certain regions for its edible beans.

Being a legume vegetable it is recognized as vital source of nutrients, rich in health provoking phytochemicals and equipped with wide spectrum of micronutrients that can have far-reaching impact on fulfilling nutritional and health demands of humankind. It is a multifaceted crop that can be utilized for vegetable, pulse and fodder purpose. Despite its huge potential, the crop remains unexploited by both farmers and consumers owing to a variety of reasons that comprise of low yield coupled with longer duration, photosensitive nature of plants and distinctive consumer preferences. Although it is a drought tolerant crop cultivated in dry lands with sparse rainfall, the crop prefers relatively cool season for flowering that starts fruiting in winter due to its photosensitive nature strictly hampering the kharif cultivation. In India, both bush and pole varieties are grown on a commercial scale with the former being photo-insensitive and grown during both kharif and rabi.

Types of Dolichos bean

i). Bush Beans (ii). Pole beans

(I). Bush beans

Bush beans are green beans that grow on a short, bushy plant. Common bush bean varieties include Blue Lake Bush, Roma II (Romano), Masai (Filet), and heirloom Kentucky Wonder Bush. Bush bean plants:

Grow up to two feet tall. Since bush beans only reach up to two feet tall and two feet wide, you can plant them very close together in a smaller garden.

Don’t require support. Bush bean plants grow short and squat, so they don’t require a trellis or other support to thrive.

Have a shorter production time. Bush beans mature slightly faster than pole beans, and are usually ready to harvest within 40 to 60 days of planting.

Produce all their beans in two weeks. Bush beans generate all of their produce over a relatively short time period, usually within one to two weeks, after which the plant will cease to produce.

Can be disease-prone. Bush beans can be susceptible to a wide variety of plant diseases and viruses, including powdery mildew, anthracnose, and mosaic virus (transmitted by aphids).

(II) Pole beans

Pole beans, also known as runner beans, are green beans that grow tall on climbing vines. Common pole bean varieties include Kentucky Blue, Blue Lake Pole, Scarlet Runner, and heirloom Kentucky Wonder Pole. Pole bean plants:

Grow up to 12 feet tall. Pole beans are large and impressive plants, usually growing at least six feet tall and often up to 12 feet. Pole beans need ample space to grow, and won’t grow well in compact areas.

Require trellises or other support. Since pole beans grow tall, they’ll need a form of support to grow on (hence their name, “pole beans”). Common pole bean support systems include a trellis, fence, teepee, or a sturdy cornstalk.

Have a longer production time. Pole beans take slightly longer than bush beans to produce their crop, usually between 10 and 15 additional days.

Have a longer harvest. Pole beans draw a lot of energy from their vines and leaves, meaning they can continue producing beans over a period of time as long as one month, with continual harvesting.

Are more disease-resistant. Pole beans are slightly hardier than their bush bean relatives, and aren’t as susceptible to the range of diseases that can plague bush beans

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SEED PRODUCTION OF MUSTARD AT PROPOSED KRISHI VIGYAN KENDRA, FARM, NIWARI, MADHYA PRADESH: CASE STUDY

Article ID: AG-VO4-I04-11

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Introduction

Objectives of Proposed – Krishi Vigyan Kendra, Harshmau, Niwari

(i) Long term Objective

- To provide problem solving technological knowledge which are essential to manage emerging challenges in agriculture and allied sectors of the district.
- To identify technological gaps and reasons thereof, prioritize problems for different micro – farming situations.
- To provide technological options for improving productivity and economic security, technology assessment & refinement
- To demonstrate frontline extension activities and provide technological backup in the district at micro–farming situation level to improve the socio–economic conditions of the farming community.

(ii) Short term Objective

- To enhance knowledge and up-gradation of skills of farming community
- To increase productivity of major food and feed crops, vegetables, fruits, cattle, poultry etc. within available resources.
- To demonstrate production potential of the technologies at the farmers' field.
- To create self-employment opportunity for the rural youth.

- To increase income of farming community through technological interventions and diversification.

1. Thrust areas

- Ensuring quality education and research at undergraduate, post graduate and doctoral levels in agriculture and allied sectors.
- Development of high-yielding varieties of pulses, oilseeds and millet crops through integration of science-based techniques.
- Improving output of horticultural crops (fruits, vegetables, flowers) prominently grown in the Bundelkhand region.
- Producing quality seeds by establishing Seed-Hubs for major crops of the region with the targeted enhancement in productivity.
- Deployment of modern tools of remote sensing, geographic information systems, nanotechnology, biotechnology and bioinformatics in precision agriculture.
- Development of nutrient-deficient soils to identify plant indicators and performing nutrient-response studies in major crops.
- Sustainable utilization and conversion of Bundelkhand specific bio-wealth and bio-waste into value-added products.
- Improvement in inland fisheries, and milk yield from cow and goat for increasing farmers' income.
- Establishment of strategic alliances of public-producers-processors and soldiers through creation of incubation centres.
- Harnessing public-private-people partnerships for holistic development of the region
- Fostering national and international collaborations for capacity building and scientific developments.

2. Extension service

- Quality seed distribution of pulses, oilseeds and millet crops through seed-hubs.
- Popularization of improved varieties of chickpea, mustard, groundnut, sesame, urd bean, mung bean along with proven technologies through front line demonstrations.
- Maintaining seasonal crop cafeteria to create awareness among visiting farmers.
- Organizing stakeholders' trainings on regular basis.

- Hand on training, Farmers day, Field Days, Farmers fairs and Mass Media tools for dissemination and popularization of new technology.
- Publication of farmers' friendly updated literature in local language.

3. Population data:

Classified population data of the District in terms of (as per recent Census 2011):

(i) Rural and Urban population - Rural: 325589, Urd bean: 1092

(ii) Farming/Non-Farming population - Farming - 85860

(iii) Total population of the district - 434807

(iv) Large farmers/Smaller farmers/Marginal farmers/Hilly farmers-Table-1.

Year / Block	Unit in hectare							
	Less than 0.50		0.50 to 1.00		1.00 to 2.00		2.00 to 4.00	
	Number	Area	Number	Area	Number	Area	Number	Area
1	2	3	4	5	6	7	8	9
Total farmers	35691	19152	32541	28193	12709	19681	3952	11995

Year / Block	Unit in hectare					
	4.00 to10		10 or more		Total Number	
	Number	Area	Number	Area	Number	Area
1	10	11	12	13	14	15
Total farmers	785	3852	182	19709	85860	102582

Large farmers/Smaller farmers/Marginal farmers/Hilly farmers-Table-1 continue…..

(v) Literacy rate for the district as a whole, for rural and urban population, for males and females etc.:

Total population of the district Niwari is 434807 and most of the people live in rural area as only 20711 live in Niwari town. As of the 2011 Census of India, Niwari town had a population of 20,711 with the 1318 km² area. Males constitute 53% of the population and females 47%. Niwari has an average literacy rate of 60%, higher than the national average of 59.5%: male literacy is 69%, and female literacy is 50%. In Niwari, 7% of the population is under 6 years of age. Details are given in following **table-2.**

Description	Rural	Urban
Population (%)	74.90	26.10
Total Population	325589	109218
Male Population	171802	41545
Female Population	153787	37673
Sex Ratio	905	904
Child Sex Ratio (0-6)	870	882
Child Population (0-6)		
Male Child(0-6)	-	-
Female Child(0-6)	-	-
Child Percentage (0-6)	892	895
Male Child Percentage	51.80	51.84
Female Child Percentage	48.20	48.16
Literates	171309	69.99
Male Literates	107969	27
Female Literates	68254	24
Average Literacy	36.48	74.40
Male Literacy	73.80	81.30
Female Literacy	48.30	64.70
Population of SC	46306	-
Male population	24320	-
Female population	21986	-
Population of ST	6769	-
Male population	3525	-
Female population	3244	-

(e) Main occupations of the people in the district:

(Give more details about the type of farming, major crops and related facilities available like canals, electricity, tanks etc.)

4. **Main occupations of the people in the district:**

Table-3: Land use pattern-

Land use pattern of the district (Latest statistics)	Geographical area	Cultivable area	Forest area	Land under non-agricultural use	Permanent pastures	Cultivable wasteland	Land under Misc.tree crops and groves	Barren and uncultivable land	Current fallows	Other fallows
Area in (000 ha)	131	82	20	9	7	5	0	13	3	2

Table-4: Area & percentage of major soils in the District Niwari.

Major Soils	Area('000 ha)	Percent(%) of total
Black/Mar/Kabar soils	32.75	25
Parwa soils	45.85	35
Red soils/ Rankar	52.40	40
Total	131.00	100

5. **Total cropping intensity of Niwari is 189%**

Irrigation	Area (000ha)		
Net irrigation area	71.70		
Gross irrigated area	71.70		
Rainfed area	11.00		
Source of irrigation (Gross Irrigated Area)	Number	Area (000ha)	Percentage of total irrigated area
Canals	18	14350	20.0
Tanks	16	5200	7.20
Open wells	14700	20523	28.60
Bore-wells (Tube wells)	15400	18622	25.90
Lift irrigation Schemes	5	4500	6.30
Micro-irrigation	26	2880	4.00
Other sources	40	5700	7.90

Total irrigated area	-	71775	-
Pump-sets (2011-12)		28000	
No. of Tractors		1400	
Ground water availability and use (Data Source: State/central Ground water Department/Board)	**No. of blocks-Tehsils**	**(%)area**	**Quality of water**
Over exploited	-	-	-
Critical	1	50	Normal
semi-critical	-	-	
Safe	1	50	Normal
waste water availability and use	NA		
Ground water quality			Normal
***over-exploited groundwater utilization> 100%; critical: 90-100%; semicritical:70-90%; safe:<70%**			

6. **Table-6: Area under major field crops: (As per latest figures 2020-21).**

Major field crop cultivated	**Area (000 ha)**							
	Kharif			**Rabi**			**Summer**	**Total**
	Irrigated	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**		
Urd (Urdbean)	**44000**	**0**	**44000**	**0**	**0**	**0**	**0**	**44000**
Groundnut	**20000**	**0**	**20000**	**0**	**0**	**0**	**0**	**20000**
Til (sesame)	**5000**	**0**	**5000**	**0**	**0**	**0**	**0**	**5000**
Mung (mungbean)	**2000**	**0**	**2000**	**0**	**0**	**0**	**0**	**2000**
Soybean	**1500**	**0**	**1500**	**0**	**0**	**0**	**0**	**1500**
Wheat	**0**	**0**	**0**	**73500**	**500**	**74000**	**0**	**74000**
Gram	**0**	**0**	**0**	**2200**	**500**	**2500**	**0**	**2500**
Mustard	**0**	**0**	**0**	**1200**	**300**	**1500**	**0**	**1500**
Peas	**0**	**0**	**0**	**1000**	**0**	**1000**	**0**	**1000**

Table-7: Horticultural crops-

Fruits	Area (000 ha)		
	Total	Irrigated	Rainfed
Guava	200	200	0
Lime	175	175	0
Aonla	65	65	0
Ber	300	0	300
Vegetables			
Brinjal	500	500	0
Chilli	400	400	0
Tomato	500	500	0
Potato	300	300	0

Table-8: Major fodder crops-

Name of crop	Area (ha)	Total
Kharif	400	400
Rabi	200	200
Summer	0	0
Total	600	600

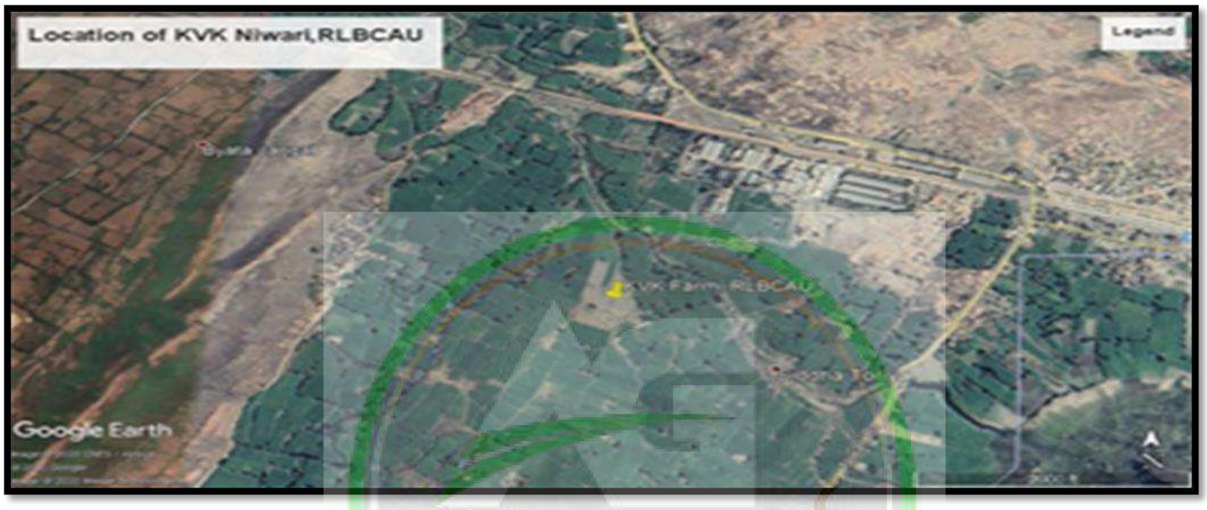
Table-9: Production and productivity of major crops (Avg. of last 5 years)

Major field crops cultivated	Area ('000 ha)								
	Kharif		Rabi		Summer		Total		Crop residue as fodder ('000 tons)
	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	Production ('000 t)	Productivity (kg/ha)	
Urad	48.40	1100	0	0	0	0	48.40	1100	12
Groundnut	36	1800	0	0	0	0	36	1800	12
Sesame	3	600	0	0	0	0	3	600	0
Moong	0.80	400	0	0	0	0	0.80	400	0
Soybean	1.80	1200	0	0	0	0	1.80	1200	0
Wheat	0	0	222	3000	0	0	222	3000	230
Gram	0	0	3.50	1400	0	0	3.50	1400	3.50
Mustard	0	0	1.30	900	0	0	1.30	900	0
Peas	0	0	2.30	2300	0	0	2.30	2300	2.30

Give a map of the district, indicating the location of the proposed KVK and distance from district headquarters in kms.

- Distance between Jhansi to District HQ Niwari – 30 Km
- Distance between District HQ Niwari to KVK (Proposed KVK) - 2 km approx.
- Distance between RLBCAU Jhansi to KVK (Proposed KVK) - 63 Km

Fig.-1: Land demarcation of the KVK, RLBCAU at Niwari District, Madhya Pradesh.



Selection of the farmers for cultivation in *Rabi*-2020 at KVK Farm, Niwari: Those farmers who were involve in cultivation of crops at this farm before land allotted to KVK, RLBCAU, Jhansi. Farmers are selected on their need basis and also a contract form filled by the farmers for sowing of crops in *Rabi*-2020. According to contract with farmers all the activities including field preparation, sowing, irrigation, harvesting & threshing will be done by the farmers and seed, fertilizers & chemicals (if possible) availability will be done by the University. Total 34 farmers have been selected for cultivation in *Rabi*-2020 at KVK, Farm, Niwari. The details of the farmers are given as below in table-10:

Table-10: Selection of the farmers for cultivation in *Rabi*-2020 at KVK Farm, Niwari.

S.No.	Name	Fathers	Village	Block	District	Mobile no.	Aadhaar no.
1.	Kallu	Ramcharan	Lakshmanpura	Niwari	Niwari	6279393395	859623456892
2.	Bhagwandas	Rancharan	Lakshmanpura	Niwari	Niwari	7224931815	563698542312
3.	Rabbu	Chidamen	Lakshmanpura	Niwari	Niwari	8085548959	433289647623

4.	Kanhaiyalal	Ramgopal	Lakshmanpura	Niwari	Niwari	8839638751	203289567845
5.	Ramgopal	Ganpat	Lakshmanpura	Niwari	Niwari	8349129441	896580551373
6.	Balaram	Ganpat	Lakshmanpura	Niwari	Niwari	7999057876	254569874523
7.	Jaiprakash	Ganpat	Lakshmanpura	Niwari	Niwari	6265232065	875489234586
8.	Damma	Ganpat	Lakshmanpura	Niwari	Niwari	8349129441	484589728945
9.	Hiralal	Soore	Lakshmanpura	Niwari	Niwari	7489493154	804528795678
10.	Jamuna	Soore	Lakshmanpura	Niwari	Niwari	7771020855	843461185197
11.	Raiti Devi Raikwar	Munna	Lakshmanpura	Niwari	Niwari	7771020855	482891089077
12.	Shyamlal	Soore	Lakshmanpura	Niwari	Niwari	9893654770	284569785612
13.	Golu	Soore	Lakshmanpura	Niwari	Niwari	6232782356	841236458978
14.	Rajjan Raikwar	Adkoo	Lakshmanpura	Niwari	Niwari	6232617280	388886252509
15.	Anandi Raikwar	Sariya	Lakshmanpura	Niwari	Niwari	9893667055	233787042321
16.	Ragnandi Raikwar	Sariya	Lakshmanpura	Niwari	Niwari	9893667055	784578612578
17.	Sullu Ahirwar	Hirye	Lakshmanpura	Niwari	Niwari	9425990298	807895789856
18.	Rampal	Govind	Lakshmanpura	Niwari	Niwari	9993653342	247892457689
19.	Surendra (Pappu)	Vidhyadhar	Lakshmanpura	Niwari	Niwari	9893679802	791287597845
20.	Sunil	Chandu	Lakshmanpura	Niwari	Niwari	9425880965	845978298561
21.	Prem	Bhaiyalal	Lakshmanpura	Niwari	Niwari	8770738298	794153609140
22.	Jagdish Ahirwar	Budhe Ahirwar	Ward no.-10, nai basti	Niwari	Niwari	9893254746	836423471951
23.	Chandrabhan	Soori Ahirwar	Ward no.-10, nai basti	Niwari	Niwari	9589502648	422689626224
24.	Lakshman Prasad Ahirwar	Soori Ahirwar	Ward no.-10, nai basti	Niwari	Niwari	9589502648	217155109159
25.	Trivikram	Ramkumar	Ward no.-10,	Niwar	Niwari	9340495625	235365012279

			nai basti			8602216239	331625208212
27.	Murlidhar (Bhura)	Halke Prasad	Ward no.-10, nai basti	Niwar	Niwari	9589275351	655971790315
28.	Sooraj Prasad Yadav	Shri Swami Prasad Yadav	Ward no.-10, nai basti	Niwar	Niwari	9179884510	939131071670
29.	Dayaram	Ganshyam	Ward no.-10, nai basti	Niwar	Niwari	9356987452	207856487358
30.	Ramswaroop	Baidhyanath	Ward no.-10, nai basti	Niwar	Niwari	9755757043	208200209105
31.	Ganpat	Ramcharan	Ward no.-10, nai basti	Niwar	Niwari	9589632452	938756784236
32.	Chaturbhuj	Umrao	Ward no.-10, nai basti	Niwar	Niwari	9756354892	841279137894
33.	Santosh	Umrao	Ward no.-10, nai basti	Niwar	Niwari	9752638945	657843567892
34.	Kashiram	Umrao	Ward no.-10, nai basti	Niwar	Niwari	9365847856	937892854612

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SEAWEED IS AN ALTERNATIVE TO CHEMICAL PESTICIDES AGAINST INSECTS AND PLANT PARASITIC NEMATODES

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Abstract

The multicellular, macroalgae that mainly grows in marine regions is popularly known as "Seaweed". The products of seaweed have been utilized in many industries like food, pharmaceuticals, cosmetics, and nutritional supplements. In this line, nowadays they attain great growth in the agricultural industry also. The seaweed extracts may act as a soil fertilizer, plant growth stimulator, enhance plant growth, and also protect the plants from diseases, insects, and plant parasitic nematodes because of their biochemical compounds like terpenes, phenolic compounds, etc. Hence, the seaweed extract will be an alternative botanical pesticide against various insect pests and plant parasitic nematodes. Thus, this paper will provide insight into the advancement of plant protection attained through seaweeds.

Introduction

Seaweed is a common name for the multicellular, macroalgae and mainly grows in marine regions. Red, green, and brown are three types of marine algae that were considered the most important and major groups of seaweed (Dhillon*et al.*, 2012). The utilization of seaweeds at the world level is becoming a recently developing industry that provides multi-billion dollars. The research and utilization of marine algae have been increased anew one from several decades (Jimenez-Escrig and Sanchez-Muniz, 2000). Seaweed products have been applied in many industries like food, pharmaceuticals, cosmetics, and nutritional supplements (Smit, 2004). In agriculture, Seaweed helps to promote plant growth and increase soil fertility due to the presence of micro and macronutrients, humic acid, and phytohormones. Nowadays, seaweed attains a major role in the alternative to chemical pesticides for plant parasitic nematode management. The plant parasitic nematodes are the most economically important organisms next to insects and diseases. Decraemer and Hunt (2006) state that 4100 species of plant parasitic nematodes have been reported so far. The plant parasitic nematodes cause annual crop losses of about USD 100 billion (Saifullah *et al.,* 2007). The withdrawal of the chemical mode of nematode management is costly and also not safe for the environment by increasing the soil temperature which leads to climate change. In this connection, a need for sustainable and environmentally friendly management options. There are many botanical and biological derivatives are used for the management of plant parasitic nematodes. Thus, seaweed also attains one of the most useful organisms in nematode management nowadays. In this article, we discuss the utility of seaweeds in the management of insect pests and phyto nematodes.

WHY SEAWEED?

The high fiber content of seaweed acts as a soil conditioner and also assists the moisture retention. They are the proven most effective bio-fertilizers because of their mineral content and source of secondary elements (Mat-atko,1992). They also contain bio-control properties, organic compounds, and plant growth regulators like auxin and gibberellins. The Chlorophyta, Phaeophyta, and Rhodophyta seaweed groups contain so many biochemical compounds like carotenoids, fatty acids, fibers, alkaloids, and phenolic compounds that could be the source of novel insecticidal properties (Ghareeb *et al.,* 2020). They also have antibiotic compounds like bromophenol, tannins, terpenoids, and phloroglucinol which act as an anti-nematicidal property (Leicach *et al.,* 1998). The seaweeds like *Sargassum acinarium, Turbinaia turbinata, Petrocalida capillacea* and *Cystoseira Myrica* showed bio-active compounds like diissooctyl phthalate, terpenoids, decane, phenolic compounds, and fatty acids which have insecticidal properties (Elbrense *et al.,* 2021). Thus, seaweeds may act as one of the best and safest nematicides for the management of insects and phyto nematodes.

EXPERIMENTS AGAINST INSECTS

The utilization of seaweed extract was severely damaging the exoskeleton of the insects and caused the mortality of the pests. The research on the effect of *Sargassum latifolium* extract showed promising insecticidal activities against *Sarcophaga bullata*, *Tribolium castaneum*, *Musca domestica*, and *Solenopsis invicta* was reported by Abd El-Aziz *et al.* (2023). They reported the utilization of *S. latifolium* extract severely damaged the exoskeleton of these insects and caused mortality by inhibiting the chitin synthase enzyme of the insects. The experiment done by Elbrense *et al.* (2021) in crude extracts of seaweeds like *Sargassum acinarium*, *Turbinaia turbinata*, *Petrocalida capillacea*, and *Cystoseira Myrica* was tested against Egyptian cotton leaf worm, *Spodoptera littoralis* and lesser grain borer, *Rhyzoptera dominica*. The extracts were tested as the insect-contact method and antifeedant method. The results showed that all the seaweed extracts exhibited insecticidal and antifeedant activities against the third instar larvae of *S. littoralis*. Ethanolic extract of *T. turbinata* caused the highest mortality rate (83.33±1.92%) in 3rd instar larvae of *S. littorlais*, *S. acinarium* caused the highest mortality (53.33±6.93%) rate of 5th instar larvae of the same insect and in adults of *R. dominica* (30.00±3.33%) was noticed. *P. capillacea* acted as the highest antifeedant seaweed against the tested insects. They also found a direct relationship between the mortality percentage of insects and the seaweed concentration and exposure time. Thawfeeq Ahmed *et al.* (2022) tested the seaweeds of *Sargassum tenerrimum* and *Gracilaria corticata* against *Aphis craccivora* adults on cowpeas. The result showed the methanolic extracts of these seaweeds caused more than 60% mortality of *A. craccivora* at a higher concentration of 1.6%. Hence, they concluded these seaweed extracts will be an alternative botanical pesticide for the management of aphids.

EXPERIMENTS ON NEMATODES

Several experiments were conducted to test the nematicidal activities of different types of seaweeds from various countries of this world. Many plant parasitic nematodes cause severe yield loss to many agricultural and horticultural crops. Among them, root-knot nematode (*Meloidogyne* species) is one of the major plant parasitic nematodes that infest almost all the crops that are cultivated under different climatic regions. Because of this reason, many research works on the anti-nematicidal properties of different seaweeds also experimented on root-knot nematode, *Meloidogyne* species. Here we listed fewer research works carried out on seaweeds against root-knot nematodes. Khan *et al.* (2015) studied the nematicidal activity of 32 species of seaweeds against *M. javanica*. They tested the biochemical potential of seaweeds in two different solvents (water and methanol) at the ratios of 2.5, 5, and 10%. The results showed that *Sargassum tenerrimum*, *Padina tetrastromatica*, and *Melanothamnus afaqhusainii* showed maximum egg hatching (96%) and juvenile mortality was 99% and 100% in water and methanol extract @ 10% concentration at the time of 72 hours of exposure. Afia and El-Nuby (2016) tested the nematicidal activities of six seaweed species (*Cystoseria Myrica*, *Cystoseria trinode*, *Padina pavonia*, *Digena simplex*, *Caulera serrulata* and *Thallathodendron ciliatum*) that were collected from the shallow water of the Hurghada coast against *M. incognita.* The *in-vitro* study results showed that the 10% concentration of the seaweed achieved the highest mortality rate of root-knot nematode juveniles. In that, *Cystoseria myrica* showed the highest mortality rate at all concentration rates (2.5, 5, and 10%), and *Digena simplex* showed the lowest mortality rate. The report of Naqvi *et al.* (1992) stated that the one percent extract of marine algae was tested for nematicidal activity against *Helicotylenchus indicus.* They reported, after 48 hours of application of marine algae extract, the activity of *H. indicus* was reduced 78% in *Cystoclonium purpureum*, 75% in *Chaetomorpha antennina*, 95% in *Centroceras clauulatum*, 90% in *Dictyota indica* and 44% in *Scinaia fasicularia*.

Conclusion

Due to the adverse conditions in climate change, the chemical method of managing insects and nematodes is also one of the factors. To create a good environment for the future world, we need to take up a stand to produce more botanical and bio-control products for managing insect pests and plant parasitic nematodes. In this concern, seaweed seems to be of great use in crop protection. The research field has to extend its research towards the seaweed-based formulations, application methods, and dosage recommendations for the management of insects and nematodes need to work in the future. Hence, we conclude this paper, to take a chance to shift chemicals with seaweeds for crop protection thus providing wonderful opportunities for creating a green world.

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AQUAPORINS IN PLANTS

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Introduction

Aquaporins are membrane channel proteins that facilitate the transport of water and small neutral molecules across biological membranes of most living organisms. Aquaporins were found to be involved not only in transport of water but also in transport of glycerol, CO_2, urea, ammonia, hydrogen peroxide, boron, silicon, arsenite, antimonite, lactic acid and O_2. Aquaporins play a major role in physiology of plant growth and responses to various biotic and abiotic stresses.

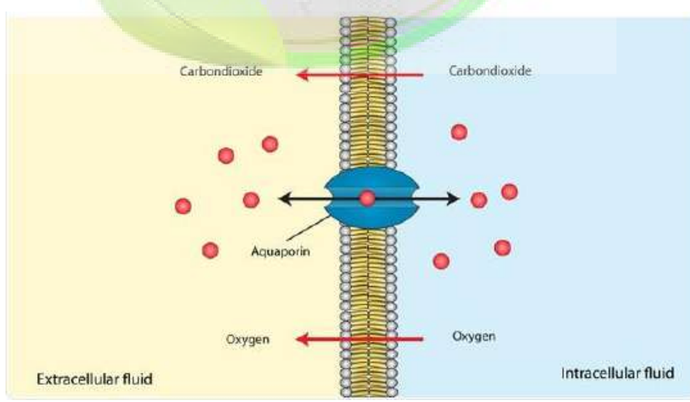

Figure: Schematic illustration on working of aquaporins

Aquaporins

Aquaporins are placed in the superfamily major intrinsic proteins (MIP). These MIP are found throughout the living kingdom except thermophilic archaea and bacteria. The MIPs have highly conserved Asn-Pro-Ala (NPA) motifs. Many aquaporin genes have been identified and well described in Arabidopsis thaliana, maize, rice, soybean, tomato, and cotton. Aquaporins in higher plants are classified into 7 subfamilies

- Plasma membrane intrinsic proteins (PIPs)
- Tonoplast intrinsic proteins (TIPs)
- Nodulin26-like intrinsic proteins (NIPs)
- Small basic intrinsic proteins (SIPs)
- Uncategorized (X) intrinsic proteins (XIPs)
- Hybrid intrinsic proteins (HIPs) and
- GlpF-like intrinsic proteins (GIPs)

It is interesting to note that only one aquaporin PIP is shared between algae and higher plants. The molecular weight of aquaporins ranges from 23 to 31 kDa. Generally, more than 30 aquaporin isoforms are present in the plants. In fact, plant species have a higher number of aquaporin genes than animals, ranging from 30 to 70.

Plasma membrane intrinsic proteins (PIPs)

Plasma membrane intrinsic proteins (PIPs) are the largest among the aquaporins subfamily. They are identified in the plasma membrane and are localised in organs such as vascular tissues, guard cells and flowers. It is interesting to note that PIPs are the only aquaporins shared between algae and higher plants. PIPs are involved in the transport of water, CO_2, glycerol and H_2O_2. They can be further classified into two sub-groups such as PIP1 and PIP2 based on the length of amino acids and C-termini, amino acid substitutions, and their water permeability

PIP1 subgroup

- PIP1 subgroup consists of 5 isoforms *viz.*,PIP1;1 to PIP1;5
- These proteins have longer N-terminal but shorter C-terminal tails
- Low water permeability compared to PIP2 subgroup

PIP2 subgroup

- PIP2 subgroup consists of 8 isoforms *viz.*, PIP 2;1 to PIP 2;8
- These proteins have a shorter N-terminal and a longer C-terminal tails
- Efficient water channel proteins compared to PIP1

- Have more water permeability
- Contains an additional stretch of 4-10 amino acids in the loop

Tonoplast intrinsic proteins (TIPs)

Tonoplast intrinsic proteins (TIPs) are found in vacuolar membrane (Tonoplast). The water permeability of TIPs is much greater than the PIPs. TIPs are involved in the transport of urea, glycerol, H2O2, NH3, water. They play a major role in stress response such as salt stress

Nodulin26-like intrinsic proteins (NIPs)

Plants of Leguminosae have symbiotic relation with rhizobacteria that fixes atmospheric nitrogen. Nodulin 26 protein is expressed in the symbiosome when infected with bacteria. NIPs are very similar to Nodulin 26 protein. NIPs form 10% of the total symbiosome membrane protein. NIPs play a major role in drought and salt stress in plants. The water permeability of NIPs was much lower compared to other MIPs. NIPs are mostly permeable to small organic solutes and mineral nutrients. In particular, they mediate the transport of Boron (B), Selenium (Se), Silicon (Si), Arsenic (As), Antimony (Sb) and other metalloids.

Small basic intrinsic proteins (SIPs)

SIPs are not structurally and functionally well characterised. They are small and basic aquaporins subfamily characterised by short cytosolic N-terminal region. SIPs have moderate water transport activity

Uncategorized (X) intrinsic proteins (XIPs)

They are newly discovered aquaporin proteins. XIPs are found in protozoa, fungi, mosses, and dicots and are absent in monocots. They play a multifuntionary role in H2O2 transport and metal homeostasis.

Hybrid intrinsic proteins (HIPs) and GlpF-like intrinsic proteins (GIPs)

Mosses (e.g., *Physcomitrella patens*) have two subfamilies in addition to the subfamilies categoried above namely, the hybrid intrinsic proteins (HIPs) and GlpF-like intrinsic proteins (GIPs). Spike mosses (e.g., *Selaginella moellendorffii*) only HIPs are present in addition to the PIPs, TIPs, NIPs, SIPs, and XIPs.

Functions of aquaporins

A. Osmoregulation

- Aquaporins plays a major role in osmoregulation
- They act as osmo-sensors and helps in maintain plant homeostasis

B. ROS detoxification and signalling

- Overexpression of aquaporin proteins confers protection against ROS scavenging
- TIPs transport H_2O_2 to vacuoles causing detoxification and conferring protection

C. Partitioning of nitrogen metabolites

- Permeability of tonoplast to NH_3 or urea causes accumulation of NH_3/NH_4^+ and remobilisation whenever required.

D. Plant growth

- Plants show continuous apical growth in roots and shoots, through active cell multiplication and cell expansion
- Cell expansion is due to increase in size of cells due to steady water uptake
- Aquaporins mainly TIPs play a major role in cell expansion

E. CO2 fixation

- Photosynthetic activity primary involves delivery of CO_2 from atmosphere to site of carboxylation in chloroplasts
- Aquaporins such as PIPs play a major role in mesophyll conductance
- High CO_2 would result in cell acidification, which in turn would reduce gm through pH-dependent gating of PIPs

F. Boron

- Boron is necessary for plant growth
- NIPs enhance the uptake, allocation and deposition for growing shoots and pollen.

G. Silicon

- Silicon (Si), an abundant element of the soil, can accumulate in some plants (mostly cereals), to promote their growth and resistance to abiotic and biotic stresses.
- NIPs serve as an efflux channel for B and Si and helps in the uptake of B and Si

H. Other metalloids

- Aquaporins also transport other metalloids such as arsenic (As), antimony (Sb), selenium (Se)
- Arsenic and antimony are toxic to plants and humans
- The accumulation of As and Sb is counteracted by excess of Si

- NIP play a major role in the above process
- Thus, NIPs play a crucial role in maintaining plant health and food quality

I. Flowers

- Aquaporins are found to play a major role in flowering of plants
- For eg., hydrangea (*Hydrangea macrophylla*) when gown in acidic soil turns blue due to the vascular accumulation of alumnium (Al) complexed with anthocyanins. Here NIP and TIP aquaporins play a major role in the transport of $Al(OH)_3$ to vacuoles.
- PIPs play a major role in anther dehydration, which is necessary process for anther dehiscence and maturation of pollen

J. Seeds

- TIPs helps in the seed maturation with the formation of protein storage vacuoles
- Aquaporin proteins also helps in seed germination by rapid imbibition of water into dessicated tissues. Also, during this process a shift from TIP3 to TIP1 expression helps in the transition from protein storage vacuoles to a large central vacuole
- PIPs are found to affect the rate and speed of germination also.

K. Nitrogen fixation

- Legumes have the ability to fix atmospheric nitrogen (N2) by forming symbiotic relationship with rhizobacteria.
- Upon infection the root cells differentiate into intracellular bacteroids surrounded by plant symbiosome membrane.
- During this process NIP homolog nodulin 26 protein is expressed which then transports both water and NH3 for osmoregulation and nitrogen fixation.

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EASTERN BLOTTING - AN OVERVIEW

Article ID: AG-VO4-I04-14

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Introduction

Eastern blotting, a technique used to detect and analyse post-translational modifications (PTMs) of proteins, specifically protein glycosylation in molecular biology and biochemistry. It is named after its similarity to the Western blotting technique used for protein detection as an extension of the more popular western blotting technique. It was first described and popularized by Thomas *et al*. 2009. It allows researchers to detect and analyse protein glycosylation by separating proteins based on their size and charge using gel electrophoresis. It is particularly useful in the field of glycobiology, where understanding glycosylation is essential for unravelling the complexities of biological systems.

Purpose of eastern blotting technique:

1. **Detection of post-translational modifications**: This technique allows the identification and analysis of post-translational modifications (PTMs) in proteins and helps the research in understanding how proteins are modified after translation, such as the addition of lipids, carbohydrates, phosphates or other modifications.
2. **Characterization of protein diversity:** It detects the presence or absence of specific biomolecules in proteins, through which researchers can gain insights into the diversity and variations within protein populations.
3. **Identification of specific biomolecules:** It enables the valuable information regarding role of specific biomolecules in protein function, signalling pathways of disease processes.

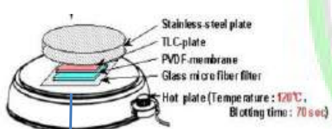
4. **Comparative analysis:** It allows for the comparison of protein modifications between different samples or experimental condition which identifies potential PTMS through such analysis.
5. **Research and biomedical applications:** It plays a crucial role in advancing our understanding of cellular processes, disease mechanisms, and potential therapeutic targets.

Principle of eastern blotting:

The principle of Eastern blotting is based on the separation of proteins by gel electrophoresis, followed by their transfer to a solid support membrane and subsequent detection of post-translational modifications (PTMs), specifically protein glycosylation. By following the Eastern blotting principle, researchers can specifically detect and analyze protein glycosylation patterns, providing valuable insights into the role of PTMs in protein function and cellular processes.

TLC plate: Solvent system: 1-propanol/ethyl acetate/water/acetic acid (40:40)30:1

Sprayed with blotting solution iPrOH/MeOH/H20 (1:4:16)



Transferred to PVDF-membrane

Addition of Na_2co_3-$NaHCo_3$ buffer solution containing BSA and EDC

Shaken for 14 hours

Washed with PBS

Blocking with PBS containing 5% skim milk

Shaken for 3 hours

Washed with PBS containing 0.05% Tween 20 (T-PBS)

Addition of Anti-SA Mab

Shaken for 1 hour

Requirements for eastern blotting:

1.Thin Layer Chromatography Plate

2.Transfer Membrane

3. $NaIO_4$ solution

4. Blotting Solution

5. Na_2CO_3/ $NaHCO_3$

6. Stainless steel plate

The process of eastern blotting:

Protein separation: Proteins are first extracted from cells or tissues and separated by gel electrophoresis. Typically, sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) is employed to separate proteins based on their molecular weight.

Transfer to a membrane: After electrophoresis, the separated proteins are transferred from the gel to a solid support membrane, such as nitrocellulose or PVDF (polyvinylidene difluoride). This transfer process, known as blotting, helps immobilize the proteins onto the membrane surface.

Blocking: The membrane is then treated with a blocking agent, usually a protein such as bovine serum albumin (BSA) or non-fat dry milk. This step prevents non-specific binding of antibodies and reduces background noise.

Detection of glycans: The membrane is probed with specific lectins or antibodies that can recognize and bind to specific glycan structures. Lectins are proteins that have a high affinity for specific sugar molecules. By using lectins or glycan-specific antibodies, researchers can identify and visualize the glycosylation patterns of proteins.

Visualization: The bound lectins or antibodies are detected using various detection methods, such as enzymatic reactions or fluorescent probes. This allows the visualization of glycosylated proteins as bands or spots on the membrane, indicating the presence and distribution of specific glycan structures.

Analysis: The detected signals can be quantified and analyzed using imaging software or densitometry techniques to determine the relative abundance or changes in glycosylation patterns between different samples.

Applications of Eastern Blotting technique

1. The most important application of eastern blotting is the analysis of post-translational modifications in proteins.
2. The technique has been used to identify and purify different plant products.
3. Eastern blotting also allows the detection of modifications in proteins of different origins.
4. It also helps to study the nature of interactions between different molecules by the use of ligands.
5. Eastern blotting has been extensively used to compare modifications in proteins obtained from different bacterial species.
6. It is also used to detect carbohydrate epitopes in different proteins.

Limitations of eastern blotting

1. Limited specificity
2. Lack of quantitative data
3. Limited resolution
4. Sample loss during transfer
5. Limited information on glycan structure
6. Time-consuming and labor-intensive
7. Limited applicability to specific PTMs

Future aspects of eastern blotting technique

Eastern blotting has been a valuable technique in the field of glycobiology, allowing researchers to investigate protein glycosylation patterns and understand their functional significance.

1. High-throughput analysis
2. Advanced detection methods
3. Glycoprotein profiling
4. Disease biomarker discovery
5. Therapeutic targeting
6. Technological advancements

Overall, the future prospects of Eastern blotting lie in its further refinement, integration with other techniques, and application to relevant biological and clinical research. Continued advancements in this area will contribute to a deeper understanding of protein glycosylation and its implications in health and disease.

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FOOD ADULTERATION: IMPACT ON PUBLIC HEALTH

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Abstract

Food is essential for human growth and maintenance and is a basic necessity for essential nutrients. Furthermore, eating wholesome food is essential for supplying the nutrients required for the body's development, growth, and maintenance Food is essential for all living things to survive. Foods that are hygienic, fresh, and nutritious are vital to human health. Food is impacted by a number of counterfeits these days. The deliberate lowering of food quality by adding or substituting a lower-quality component or by leaving out an important ingredient is known as adulteration of food. Food adulteration is a common form of food deception that compromises food safety on a global scale. Food adulteration can be intentional, involving the addition or substitution of inferior substances, the removal of valuable components from staple foods, or a reduction in the quality of food supplied for sale. Human life is seriously threatened by these immoral and negligent means of acquiring immense wealth.

Keywords: Food, Adulteration, Adulterants, Health

Introduction

The adulteration of food is a widespread issue in both developed and developing nations. A less developed nation is particularly more susceptible to issues with food adulteration because they lack effective legislative frameworks and regulatory organizations. Many emerging nations, such as India,Pakistan, Bangladesh, Vietnam, China,Indonesia, Afghanistan etc. have high rates of food adulteration. It is a significant issue that may have detrimental effects on customers' health, the economy, and social unrest, among other things. Foods contaminated with impurities can have minor to severe health impacts. After consuming tainted food, adverse responses, diabetes, heart disease, nausea, and diarrhea are frequently seen (Momtaz et al., 2023).

The practice of adulterants and pollutants in food products leads to health issues. Financial harm can also result from food adulteration. Food adulteration undermines consumer trust in food safety and quality, which lowers demand and lowers sales. This may damage the credibility and commercial viability of the food industry, resulting in decreased employment and weaker growth in economy. Social unrest can also result from food adulteration, when people grow enraged and dissatisfied about unsafe food. Additionally, it may lead to nutrient shortages, which may worsen immunity, growth, and development as well as raise the risk of illness. Food adulteration negatively affects farmers, consumers, businesses, and the government (Hazi et al.,2023).

Food Adulteration and types

Food adulteration can be defined as the intentionally adding of prohibited substances to partially or completely replace healthy components or falsely produced fresh products (WHO, 2017).

Intentional adulteration

It refers to the deliberate addition of harmful or unsafe components to food in order to deceive one's perception of its quality. This can involve putting toxins, less expensive ingredients, or other dangerous materials in food products (Tomar and Alka, 2022)

Incidental adulteration

It is described as the unintentional or deliberate altering of food products with undesirable or hazardous ingredients while they are being produced, processed, stored, or transported. This may occur as a result of environmental pollution, cross-contamination, or inadequate hygiene standards, which can introduce pollutants or adulterants into the food supply chain (Ayza and Belete, 2015).

Metallic adulteration

It is the occurrence of metals in food that shouldn't be present. It occurs when metals such as arsenic, mercury, or lead unintentionally find their way into food supplies. They may enter food by contaminated soil, water or improper industrial management (Bansal et al., 2017).

Common Food products, Adulterants and impact on Public health

1.Food Product:Milk

Adulterant: Water,Starch,Urea

Impact on health:Digestive health problems

2.Food Product:Black Pepper

Adulterant: Dried Papaya Seeds

Impact on health:Cardiac health problems

3.Food Product: Ghee

Adulterant: Ghee essence, Vanaspati, Sweet Potato, Mashed Potato ,Starch

Impact on health:Cancer Problems

4.Food Product:Turmeric

Adulterant: Lead Chromate,Sawdust and Metal yellow

Impact on health:Stomach disorder

5.Food Product:Chilli Powder

Adulterant: Artificial Colours,Brick powder

Impact on health:Blood and Lung Cancer

These are some of the food products which every individual consumes in their day to day life. There are also various food products such as Sugar,Coffee Powder,Tea Powder,Salt,Veetable oils,Food grains,Sea Foods,Sweet Juices,Fruits etc (Bansal et al.2017) which are adulterated and when consumed by individuals triggering various health problems leading to serious negative impact on health of people.

Food adulteration is driven by various factors, including financial gain, supply chain complications, and insufficient supervision by regulators. Foods including spices, grains, dairy products, oils, and drinks are frequently contaminated. Adulterants can be anything from safe things like flour or water to dangerous compounds like pesticides, lead, and industrial colors. Eating food that has been tampered with can cause a wide range of health issues, from minor gastrointestinal distress to serious infections and even death. Prolonged exposure to harmful adulterants can result in long-term health issues such neurological disorders, organ damage, and cancer. Consuming contaminated food can have a negative impact on one's health, especially for weak groups including the elderly, pregnant women, and children.

Control Measures

Government organizations, regulatory authorities, food manufacturers, and consumers must work together to detect and prevent food adulteration. To tackle this widespread issue, it is imperative to implement stringent quality control procedures, regularly check food processing facilities, and initiate public awareness programs. Furthermore, utilizing technologies like spectroscopy, chromatography and DNA testing can improve the precision and effectiveness of adulteration detection techniques.

Conclusion

Food adulteration undermines the safety, security and integrity of the food supply chain and represents a serious threat to public health. To address this issue and protect people's health and well-being everywhere, a multifaceted strategy including collaboration between companies, government actions and consumer education is needed.

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HEAT SHOCK PROTEIN (HSPs)

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Abstract

Heat Shock Proteins (HSP) is an essential part of the plant's defence mechanism against heat stress. Serving as molecular chaperones, they aid in the correct folding of proteins and stop them from denaturing or aggregating in hot conditions. Heat stress triggers the development of HSP genes, which produce proteins that shield other cellular proteins from harm. Plant cells start to synthesise a unique protein known as protein heat shock (heat shock protein) in adequate amounts above a specific temperature of about 40° C in most four-season plants. As temperatures rise, most other organisms, including plants, produce HSPs in varying sizes. The five primary structures of HSPs synthesized by eukaryotic organisms are HSP100, HSP90, HSP70, HSP60, and Small HSP (SHSP), which is present in the cytosol, mitochondria, endoplasmic reticulum, chloroplast, and nucleus. Heat stress transcription factors (Hsfs) are regulatory proteins that regulate the transcription of heat-shock protein genes. Plants exhibit at least 21 Hsfs, each of which plays a regulatory role. Here, we specifically discuss the functional involvement of HSPs in defensive mechanism against Plant stress.

Keywords: Chaperones, Heat shock proteins, Heat stress, Heat tolerance and crop plants.

Introductions

Various environmental stresses, including drought, salinity, temperature fluctuations, and chemical pollutants, exert simultaneous pressures on plants which led to cellular damage and triggering of secondary stresses such as osmotic and oxidative stress. Despite their inability to relocate to escape these stresses, plants have evolved various morphological adaptations to tolerate them (Wang *et al.,* 2003). These adaptations include the prevalence of the more resilient sporophyte over the sensitive gametophyte, the presence of stomata in the epidermis for gas exchange, the development of dormant organs, and the existence of conducting tissues for long-distance transport. Additionally, plants employ molecular defense mechanisms crucial for their survival and growth in stressful conditions. They exhibit a range of molecular responses to combat these stresses. Of which, heat stress (High temperatures) have an impact on a plant's structure and metabolism, particularly on cell membranes and numerous fundamental physiological functions like respiration, photosynthesis, and water relations (Wahid *et al.,* 2007). The Michaelis-Menton constant (Km) of each enzyme involved in the process is temperature dependent, and this effect of heat stress is reflected in molecules (Mitra and Bhatia, 2008). Actually, all living organisms exhibit this molecular stress response, particularly in reaction to abrupt changes in genotypic expression that lead to an increase in protein group synthesis- "Heat-shock proteins" (Hsps), "Stress-induced proteins," or "Stress proteins" are the names given to these classifications (Gupta *et al.,* 2010).

Heat Shock Proteins

Heat shock proteins (HSPs) are proteins which are present in both plant and animal cells. They were first identified in connection with heat shock (Ritossa, 1962), but it is now understood that they can be brought on by a wide range of stresses, such as exposure to cold, UV light, wound healing, tissue remodelling, or biotic stimuli. The phrase "heat shock protein" is therefore misleading because hsp genes are induced to express under a variety of conditions other than heat.

Functions of HSPs

- Under both favourable and unfavourable growth conditions, HSPs are crucial elements supporting cellular homeostasis in prokaryotic and eukaryotic cells.
- It is well known that during normal cellular growth and development, HSPs are in charge of protein folding, assembly, translocation, and destruction.
- HSPs also function in the stabilization of proteins and assist protein refolding under stress conditions.
- The majority of HSPs carry out vitally crucial chaperone activities, like folding freshly produced proteins in three dimensions or stress-damaged proteins in three dimensions

Classifications of HSPs

All HSPs are characterized by the presence of a carboxylic terminal called heat-shock domain. Heat-shock proteins, which have molecular weights between 10 and 200 KD, are classified as chaperones because they aid in the signal's induction during heat stress.

Major classes of Heat shock protein	MW (KDa)	Functions
HSP 100	100-104	ATP-dependent dissociation and degradation of aggregate or damaged protein.
HSP 90	82-90	Co-regulation of thermal stress associated with signal transduction and accomplishes protein folding. Genetic buffering, metabolic detoxification, regulation of receptors, protein translocation. It requires ATP for its function
HSP 70	68-75	Assisting refolding and proteolytic degradation of abnormal proteins, preventing aggregation, primary stabilization of proteins, metabolic detoxification, ATP dependent release and binding.
HSP 60	57-69	ATP-dependent specialized folding machinery. Function as a chaperon in the post-translational assembly of multi-meric proteins.
small Heat Shock Proteins (sHSP)	15-30	Formation of high molecular weight oligomeric complexes which serve as cellular matrix for stabilization of unfolded proteins. HSP100, HSP70 and HSP40 are needed for its release.

Endoplasmic reticulum (ER) HSPs involved in plant immunity

In eukaryotic cells, the ER is a cellular organelle that performs a number of essential functions. It is a primary site of protein passing from other organelles to the extracellular space and plasma membrane because it connects to other cellular compartments such the nucleus, Golgi, mitochondria, and plasma membrane. An important feature of the ER is its multitude of quality control (ER QC) processes, which ensure that correctly folded proteins are released from the ER and end up in places like the plasma membrane, vacuoles, or apoplast. It functions by detecting irreversibly misfolded proteins and transfers them to the cytoplasm where they are broken down by proteases. ER–associated degradation (ERAD) is the aggregate term for several processes that coordinate the elimination of abnormal proteins (Huttner and Strasser, 2012). Many proteins within the ER, including HSPs and chaperones, are critical to ER function, including protein folding modes or extracellular release and cell-surface localization of proteins.

Abiotic Stress: Signalling Pathway

Numerous biotic and abiotic factors adversely affect the survival and growth of plants. Abiotic stress response is regulated at the molecular and cellular levels by signalling pathways made up of primary and secondary messengers. Stress triggers signals that, in turn, phosphorylate transcription factors in signalling pathways and successively activate those pathways. As the cell exposed to severe stress, receptors such as kinases, G-protein-coupled receptors, and regulatory molecules pick up signals from cells under stress and these receptors then activate secondary molecules like calcium, which triggers the activation of signalling pathways such as MAP, CDP, SOS3/protein kinases, TF, and stress-responsive genes. The converging molecules in the abiotic stress signalling pathway are components of MAP kinase cascades.

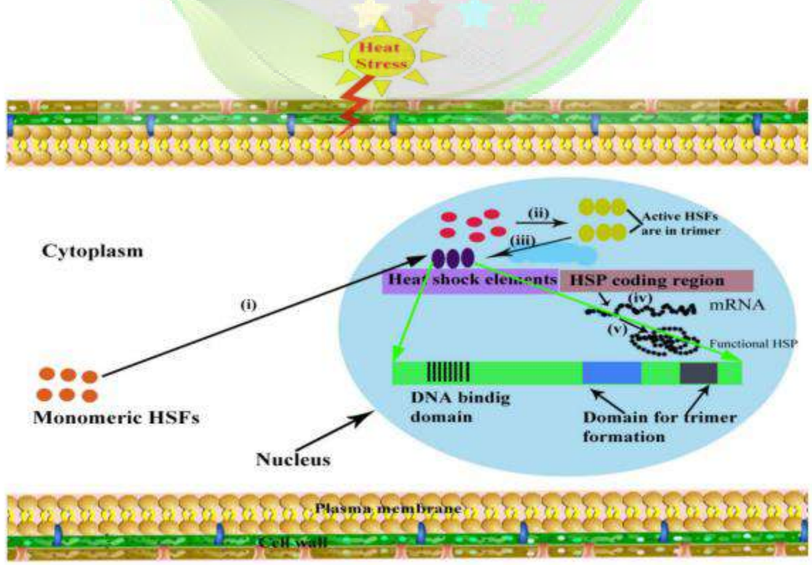

Figure 6. Illustration of the molecular regulatory mechanism of Heat Shock Proteins (HSPs) based on a hypothetical cellular model.

Under heat stress, monomeric Heat Shock Factors (HSFs) are moving from the cytoplasm into the nucleus. In the nucleus, HSF monomers assemble into an active trimer that binds to the corresponding Heat Shock Element (HSG) of the respective Heat Shock Gene's (HSE). A molecular analysis of HSE's HSF binding region reveals that it has one DNA binding domain and two domains for HSF trimerization. Functional HSPs are produced as a result of successful transcription, translation, and post-translational modifications.

Functional Role of HSPs in Heat stress

A number of studies have identified the activation of heat stress genes under high temperature stress. High expression of HSP70s has been studied in a variety of plant crops, including cotton, potatoes, tomatoes, and grains like wheat, under high temperatures. Several studies have shown the expression of HSP60 present in chloroplasts under normal conditions as well as in high temperature and drought conditions (combine impact). It is involved in the formation of chloroplasts, Rubisco assembly, and protection. Hence, under heat stress, heat shock proteins such as HSP70 and HSP60 families of chaperonins are the mostly reported types which use ATP as an energy source to maintain proteins in their correct folding locations (Khan *et al.*, 2021).

Conclusions and Future scope

HSPs are widely distributed and play a crucial function in maintaining the stability and homeostasis of proteins within cells. Plants and other organisms have several forms of HSPs that serve various purposes. Heat stress first affects a protein's quaternary structure, which has an impact on folding and denatured protein. Stress causes many signalling pathways to become active, which phosphorylates additional transcription factors and heat shock factors, which are translated into proteins and exhibit diverse responses to stress. There is a crosstalk study between various hormonal pathways, but its exact nature during simultaneous biotic and abiotic stress still needs to be identified. Even though plant abiotic stress and its relationship to signalling pathways have been extensively studied, more work has to be done using contemporary molecular proteomics and transcriptome methods to gain a better understanding of the molecular mechanism or mechanisms underlying the fundamental signalling pathways. It is necessary to understand the precise mechanism by which HSPs participate in the transmission of stress signals and the transcriptional control of several stress genes.

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INSTRUMENTS USED FOR CALIBRATION OF SUBJECTS

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Introduction

The various instruments are used for calibration of subjects, like Heart rate monitor, Benedict-Roth apparatus, Treadmill and Bicycle.

1. Heart-rate Monitor

It is a small, portable device that measures heart rate. This may be utilized in the field without the need for a telemetry system. The Heart rate monitor has three basic components.

i. Chest belt transmitter
ii. Elastic strap
iii. Receiver unit

i. Chest belt transmitter

The two electrodes are attached in a grooved rectangular region on the bottom of the belt transmitter, which takes up the subject's heart rate and transforms it to electromagnetic signals. The electrodes are wetted with water to improve sensing.

ii. Elastic strap

This is to keep the belt transmitter as high under the pectoral muscles (breasts). The belt transmitter should be tight and comfortable, and breathing should be unrestricted.

iii. Receiver

The device which receives signals from a transmitter, displays them on a screen, and records the information in a memory with the assistance of a battery. This receiver device must be within a one-meter range and can be wear as wristband (Plate 1). The heart rate monitor is controlled by two buttons below the screen on this receiver. This includes the ability to specify high and low target zone restrictions. When the subject's heart rate approaches its limits, an alert or visual warning will sound, allowing us to stop the remove beyond this point. Similarly, in certain essential situations, a low heart rate target zone will be beneficial. This receiver is also water resistant up to a depth of 20 meters.

On the other hand, an indirect evaluation of workload based on continually recorded heart rate provides an overall picture of activity levels over the course of a day's work or particular time periods of labor. Furthermore, the heart rate response is used in this manner (Rodhal, 1989).

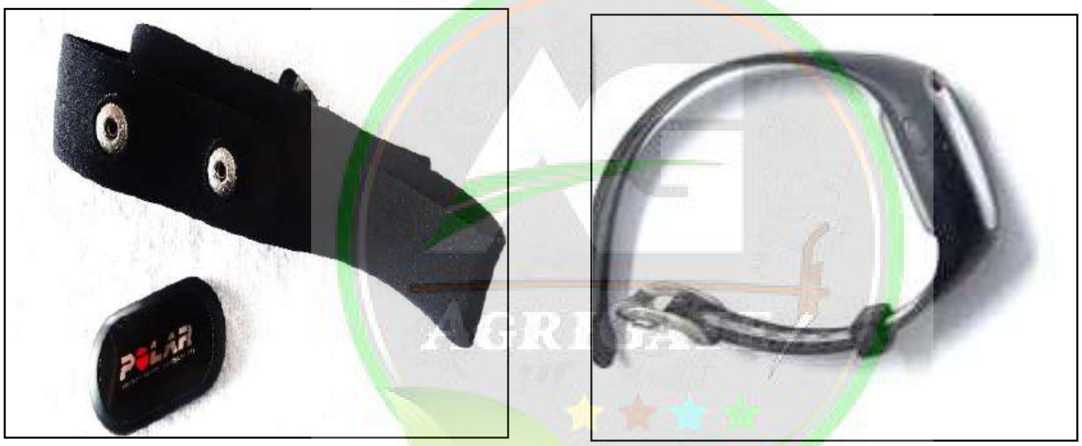

Plate. 1 Heart rate monitor

2. Bendict-Roth recording Spirometer

The oxygen uptake of the individual subject was assessed using the Bendict-roth equipment (Plate 2). The equipment consists of a 6-litre spirometer with a speed strip chart recorder. A chain suspends the spirometer bell, which is counter-weighted over a pulley. The light perspex ink writing pen is carried by the counter weight. The base is made up of aluminum casting, which contains the kymograph gear box, as well as three stop cocks, one for water and the other two for oxygen. The stopcock is connected to the two outlets on the left side of the base. The two-way stopcock (breathing valve) is carried by an adjustable arm and equipped with a rubber mouthpiece through corrugated rubber tubing. The inner diameter of all air hoses is 25 mm. The spirometer's speed is set to 20 minutes per revolution using the speed selector.

Plate. 2 Benedict-Roth apparatus

3. Treadmill

A treadmill was used to train the subjects. The treadmill is the better equipment for subject calibration (Astrand and Rodhal, 1977). The subject must walk on tread mill while breathing pure oxygen from the Benedict-roth equipment during the calibration. The subjects were trained in a VIVA treadmill. Treadmill consists of a walking belt track and the control panel. The walking belt track is 50 cm wide supported by two end rollers. The belt rolls on two sets of well-balanced rollers. A 2.2 kW motor drives the drive roller. The speed of the belt can be varied from 0 to 24 km h^{-1}. A single-phase 0.2 kW motor is used to change the slope of the belt from 0 to 20 per cent. In the front end of the treadmill, an emergency off switch is provided to stop the treadmill when the subject attains fatigue.

Plate. 3. Treadmill

The control panel houses a speedometer which shows the linear speed of the belt, and a reset switch to know the distance travelled by the subject during exercise. The panel has also a speed control knob to adjust the belt speed according to the requirement. The control panel has four other switches, one for power ON, second for power OFF, third for increasing the slope of the belt and fourth for reducing the slope. The view of the treadmill is shown in Plate 3

4. Bicycle

Bicycle was used to train the subjects. The ergometer is the superior piece of equipment for subject calibration (Astrand and Rodhal, 1977 and Guptha and Sharma, 1983). The subject must pedal a bicycle ergometer while breathing pure oxygen from the Benedict-roth equipment during the calibration. For the first time, this will be exhausting, but it may be made easier by providing sufficient instruction to the subjects.

A 4.3 kg steel flywheel (Plate 4), mainframe, handlebar post, console, pedal, seat, and seat post, as well as front and rear bases, were all included. It has a single window display that shows the time, distance travelled, and speed of operation, calories burned, and the subject's heart rate when exercising. It also included a programming feature that allowed it to raise the load on the flywheel as needed. The ergometer is powered by two 1.5V lead batteries and the display is turned on when cycling. The individuals were trained on the bi-cycle ergometer until they were comfortable pedaling the ergometer on their own. All of the individuals were appropriately educated for one month before to the commencement of the experiment, using the equipment alone and in combination.

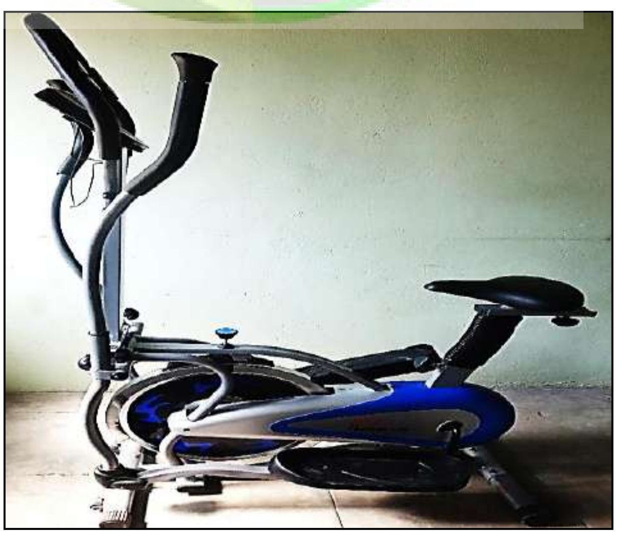

Plate 3.4 Bi-cycle ergometer

The later in the field trials may be estimated from the calibration charts due to the linear link between heart rate and oxygen intake (Bridger, 1995).

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MSP: A PATH OF HOPE IN FARMERS' EXPEDITION

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Introduction

Agriculture and agriculturists play a predominant role in the Indian economy. It contributes about 60 percent of employment to the people and 17 percent of the GDP. Agriculture accounts for about 16 percent of import and export earnings of the country. To get their demands recognised, farmers organized a group march to New Delhi on 13 February 2024. The farmers demanded a legal guarantee for buying crops at the Minimum Support Price (MSP). Among their demands, the withdrawal of India from the World Trade Organization (WTO) is also kept forward because the agreement on agriculture (AoA) minimizes the government support and subsidies given to agriculture.

What is Minimum Support Price (MSP)?

Minimum Support Price is a method of market intervention used by the Indian government to protect farmers against a sudden and severe decline in farm prices. It is the lowest amount that the government will pay farmers for their products. At the start of the planting season for several crops, the Department of Agriculture and Cooperation announces the minimum support prices. Government agencies buy all the quantity given by the farmers at the announced minimum price if the market price for the commodity drops below the minimum price due to glut and bumper production.

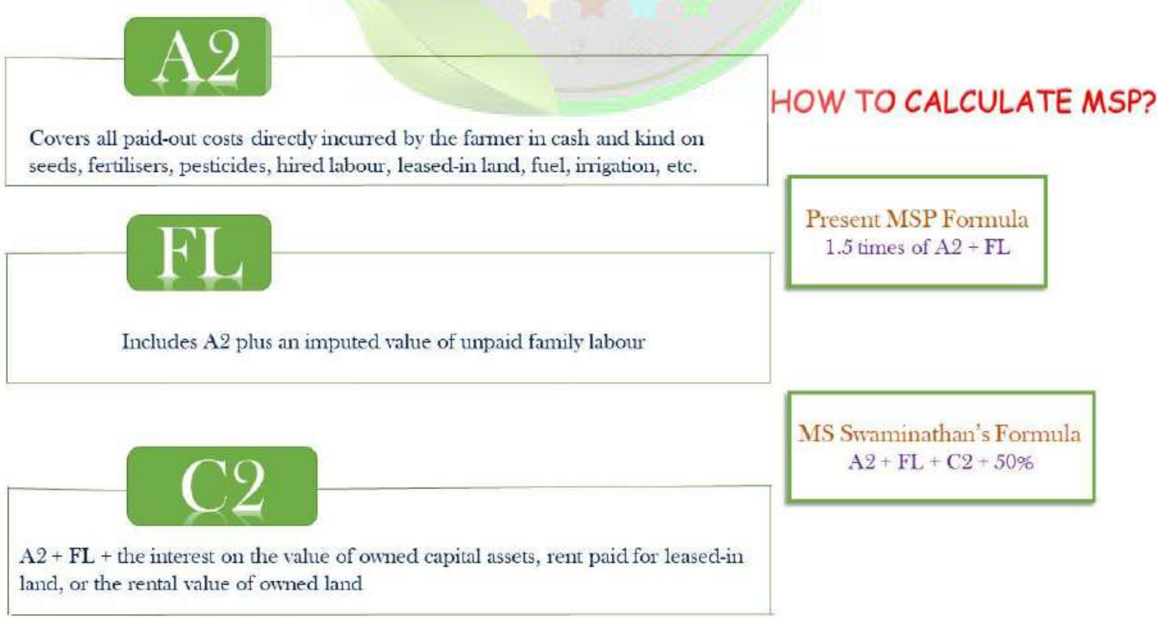
History and the origin

A series of droughts caused food shortages in India in the 1960s, as evidenced by the 1966–1967 Bihar famine. The wholesale price of food grains had experienced a significant surge. Migration and starvation were caused by increasing food prices but were mitigated by the public distribution system, government relief efforts, and non-profit organizations. A government price strategy for food grains was one of the several agricultural policy ideas that were proposed in that decade when India was experiencing the peak of the green revolution. Increasing agricultural land production was one of the primary objectives. Improved machinery, fertilizers, and high-yield cultivars were some tactics used. Support for price policies meant to boost land productivity was a component of this

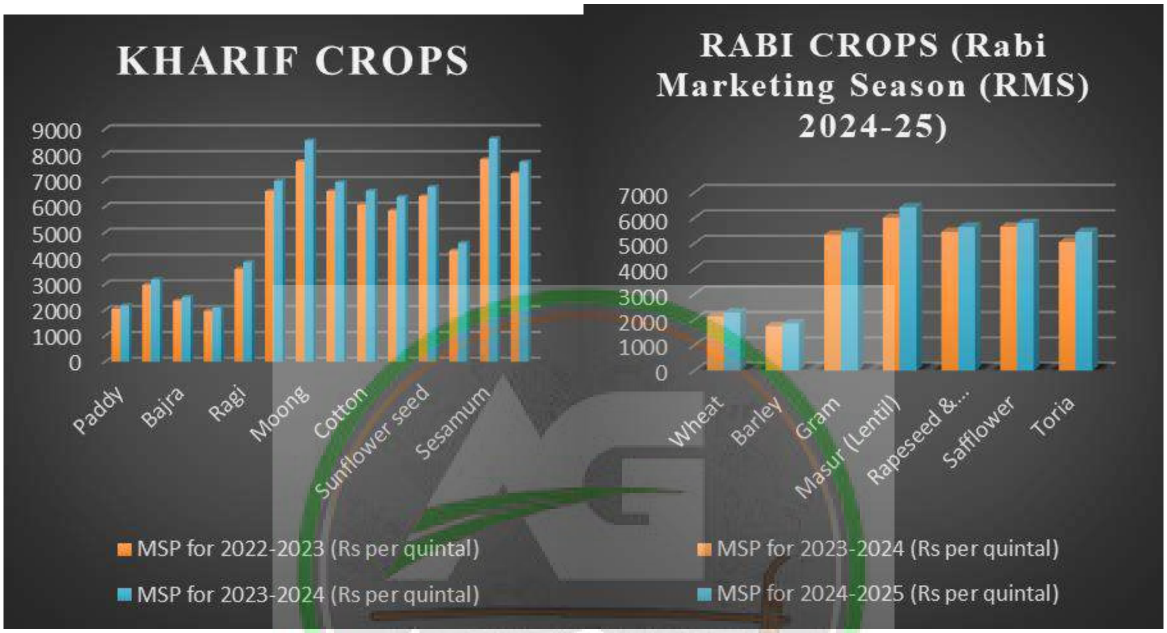
As a result, in 1965 the Agricultural Price Commission (APC) was established. The Commission implemented several price measures, including minimum support prices, predetermined procurement prices, and a distribution system to provide food grains at discounted rates. In March 1985, this committee was re-established under the new and expanded name ‘Commission for Agricultural Costs and Prices (CACP)’. Other institutions, such as central organizations and their state-level counterparts are also participating in the MSP implementation process. Among them are the National Agricultural Co-operative Marketing Federation (NAFED) and the Food Corporation of India (FCI).

The calculation of MSP is based on the recommendations of the Commission on Agricultural Costs and Prices (CACP) and approved by the Cabinet Committee on Economic Affairs.

How to calculate?



The Commission has been asked to consider certain factors while recommending the price policy by the terms of reference. This involves providing incentives for farmers to produce to national needs, permitting sensible resource allocation, and considering the effects on salaries, living expenses, and the competitiveness of their products. The Commission may also suggest non-price actions and strategies to ensure the successful execution of the pricing policy.



The National Commission on Farmers led by Dr. MS Swaminathan

Between December 2004 and October 2006, this commission turned in five reports. The final report by this Commission was based on increasing suicide rates among the farmer's community. This recommended paying farmers a fair price as a means of resolving their financial difficulties.

Why MSP?

Intermediaries including middlemen, commission agents, and representatives of Agricultural Produce Market Committees (APMCs) are frequently involved in the MSP-based procurement system. Accessing these channels may pose a challenge for smaller farms, resulting in diminished benefits and inefficiencies. The primary goal of the current MSP regime is not to correlate with domestic market pricing but to fulfil the objectives of the National Food Security Act (NFSA). It works less like an actual MSP and more like a procurement price.

It serves as a weapon for the government to regulate sudden spikes and decreases in crop prices. This aids in maintaining a floor price that prevents prices from dropping below a predetermined threshold. By raising prices, this can also be used as a strategy to manage inflation. These crops may be used by the government to sell at government fair-price stores for less than the going rate. This will also assist the government in lowering the cost of these crops so that those living below the poverty level can purchase them. Additionally, this will lessen the government's losses and aid in some recovery.

Disadvantages

Even in cases where the subsidy exceeded the restrictions outlined in the WTO Agreement on Agriculture, it was guaranteed that no nation would be legally prohibited from implementing food security programs for its citizens. Since India's applicable administered price for rice is significantly higher than the External Reference Price (ERP) for 1986–1988, price support offered through MSP will be categorized as a trade-distorting subsidy. This exceeds the insignificant level in India. Since the peace clause is subject to several restrictions, India's case cannot be supported if the MSP system is legalized for 23 crops. Only those programs that met other criteria and were in place on the decision date are eligible for the peace clause. Developing nations can use the peace clause to assist traditional staple food crops in their pursuit of public stockholding schemes for food security. Consequently, since crops like cotton, groundnuts, and sunflower seeds are not covered by the food security program, India will not be able to apply the peace clause. Without going above the insignificant limit, India can add an income-based support policy to its price-based support program. Minimum support price (MSP) and other public stockholding programs of developing countries are capped at 10% of the value of the output of specific crops under the current Agreement on Agriculture.

While 23 crops are included in the MSP, only rice and wheat are widely purchased and distributed with the National Food Security Act (NFSA). The MSP implementation for the remaining crops is haphazard and negligible. This implies that the MSP has no advantage for most farmers who plant non-target crops. The overabundance of rice and wheat produced as a result of the distorted emphasis on MSP discouraged the farmers from growing other crops and horticultural varieties having greater market demand.

A fixed predetermined price may discourage private traders from engaging, in times of excess output and a drop in market pricing, which makes legalizing of MSP, a challenge. This is not a sustainable strategy because it would make the government as the main purchaser of the majority of crops. Legalizing MSP may make it more likely to happen that crops may be distributed improperly or diverted from ration stores, warehouses, or transit. The poor would ultimately be impacted by inflation brought on by higher food grain prices due to higher procurement costs under MSP. Presently accounting for 11% of India's overall commodity exports, agricultural exports could suffer if MSP prices rise above current international values.

Way forward

To diversify agriculture and generate more money, it is important to prioritize investments in fruits, vegetables, and fisheries, as well as animal husbandry. Improved irrigation systems, simpler loan applications, prompt power supply, more warehousing capacity, and extension services including post-harvest marketing should be made possible. This can facilitate the farmers to have more choices and a stronger negotiating position. The surplus labor currently involved in unpaid agricultural work may be reemployed by industry and services. This can lead to the accelerated growth of the industries and services in the country which can in turn reduce the burden of India's agricultural sector.

Realising the fact that the, 55% of India's workforce is employed in agriculture, but the sector only contributes 17% of the country's GDP. Farmers would receive higher prices if producers' groups are supported in their efforts to control a larger portion of the farm-to-fork value chain. The government must interact with farmers and persuade them to embrace successful policy measures that are both economically responsible and compliant with WTO standards, in addition to MSP. It is imperative to acknowledge that MSP commit to function not just as a safeguard but also as a motivator for farmers to cultivate crops that enhance nutritional security. In addition, MSP provides the farmers the legal stand of authority. A clustering method should be used by the government to encourage the private sector to create effective value chains for agriculture.

When market prices drop below a set threshold, a true MSP should intervene on behalf of the government, particularly when there is excess production, overstock, or a price collapse brought on by external forces.

Conclusion

MSP plays a crucial role in aiding Indian farmers; nevertheless, it must be weighed against other agricultural inputs, agricultural policy, and regional market dynamics. MSP can remain as an effective tool to assist farmers and enhance the agricultural environment with better implementation and the required reconciliation.

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NAKIMA (*TUPISTRA CLARKEI*) – A POTENTIAL UNDERUTILIZED EDIBLE FLOWER OF SIKKIM

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Abstract

Tupistra clarkei, or nakima in the vernacular, is a member of the Asparagaceae family of plants. In Sikkim, an Indian state in the northeastern hill country, it is a significant economic plant. It is a perennial crop that grows in home gardens as well as in the wild. It favors wet, shaded environments. The inflorescence is processed into a pickle or cooked like a vegetable for eating. Together with secondary metabolites that have antibacterial, antioxidant, and antidiabetic properties, it is incredibly rich in nutrients and minerals and command a premium price on the market. As such, it has immense promise for the creation of novel medications in the fields of pharmacology and medicinal chemistry and also in the creation of value-added products.

Keywords: Nakima, inflorescence, edible, underutilized

Introduction

The utilization of flowers as nourishment is not of much of a new practice; rather, it is the revival of ancient ethnobotanical practices. Indeed, the Greeks and Romans made use of flowers for giving a beautiful ornamental influence to a variety of cuisines, as well as to amplify the organoleptic synergy between the flavor emerging from traditional dishes (such as fish, vegetables, and meat etc.) and that of floral fragrances (use of petals of rose in ancient Rome, for example Melillo, 1994). But until recently, the use of flowers in food has only been allowed within the short, seasonal window during which they almost exclusively bloom in their native environments. Edible flowers are becoming more and more popular due to a number of reasons, such as the preferences for new flavors and chances for creative cooking, as well as aesthetic and nutritional considerations (Benvenuti & Mazzoncini, 2021). The amount of general phenolic compounds found in flowers accounts for their significant nutraceutical activities with respect to antioxidant power (Falla *et al*., 2020; Mikołajczak *et al*., 2020). Flavonoids, which are composed of flavonols, anthocyanins, and flavones, have important biological activities. These compounds have a critical influence in reducing the oxidative stress associated with numerous medical conditions. Flowers are a particularly rich source of these chemicals. Flower tissues include a range of phytochemicals that have been shown to have favorable effects on human health through nutraceutical food analysis.

Nakima

One of the plants found in the Himalayan regions of Sikkim and Darjeeling, India, is *Tupistra clarkei*, also known as the Nakima vernacular in Nepali. It is one of 26 species that are native to Bhutan, Nepal, India, and China. It's a vegetable that's well-cultivated in agriculture because of its growing market worth and demand. Plants in the Asparagaceae family can be found growing between 3000-7000 feet above mean sea level in Sikkim. Nine species comprise the genus Tupistra in India: *T. clarkei* Hook.f. (Pradheep *et al*., 2020); *T. nutans* Wall. ex Lindl. (Verma and Nath, 2016; Lepcha *et al*., 2019); *T. stoliczana* Kurz (Borah *et al*., 2020); *T. ashihoi* (Roy *et al*., 2017b); *T. extrorsandra* (Averyanov *et al*., 2019), *T. khasiana* (Roy *et al*., 2017a); *T. leonidii* (Roy and Mao, 2018); *T. nagarum* (Odyuo *et al*., 2018) and *T. tupistroides* (Kunth) Dandy, among which, six of them are endemic to northeastern part of India (Roy and Mao 2018; Averyanov *et al*., 2019).

Fig. 1. Tupistra clarkei (Nakima) **(a)** plant and **(b)** Inflorescence

Source: Shukla, 2008; Dhungel, 2021

Cultivation

Its cultivation does not adhere to a predetermined set of methods. This particular plant favors shade. Usually, suckers or offshoots are used in vegetative propagation. The natural habitats of "nakima" are dry and evergreen woods, wet temperate forests, and temperate broad-leaved forests that range in elevation from 300 to 2500 meters. It is mostly confined to moist, dark regions in these forests close to streams. In South and West Sikkim districts, it is more frequently found in mixed cropping systems. It is usually found under cultivation in residential areas and forest-cleared areas between 700 to 2100 meters. Maize, rice, millets, brinjal, chilli, tomato, big cardamom, and other crops are also frequently grown. This crop thrives in high rainfall locations with well-drained, humus-rich loamy soils because it needs moisture at the roots all year long. It can be used for a range of farming techniques, including as intercropping, mixed cropping, terrace or mountain farming, due to its tolerance for mild shade. Serving the inflorescence before the flowers bloom (**Fig.2. (c)**) is the recommended method, and it is carried out once every seven days. Planting takes place in June and July, during the rainy season, for improved establishment. It doesn't need much care. To achieve the potential yield, three years are required. Harvesting occurs when the blossom peeks out from under the leaves, but before it opens completely. Inflorescences are produced by this plant from September to mid of November. It has a fleshy stem and fleshy bloom, which blooms for a short while and is made up of several bulbous flowers grouped together or in a conical shape. One well grown plant can yield approximately 1-1.5 kilogram of blooms per year. Bio-stimulants can typically be used in conjunction with organic farming to achieve better results (Shubha *et al.*, 2017).

Fig.2. (c) Desirable stage of inflorescence

Source: Pradheep et al., 2020

Utilization of nakima in terms of culinary, medicinal and nutritional attributes

The inflorescence of this plant are used as vegetables. Moisture content (79.98-81.68%), ash content (3.61-3.70%), crude fat (20.51-22.59%), crude fibre (6.05-6.55%), crude protein (0.30-0.37%), carbohydrate (40.81-43.03%), total starch (0.009-0.02%), ascorbic acid (0.41-0.48%) has been found in nakima. Nakima flowers are found to be rich in crude fat, fiber, protein, carbohydrates, and vitamin C, along with vital and nonessential minerals like potassium, copper, phosphorus, iron, magnesium, and salt (Khatoon *et al*., 2018). There are some phytochemicals from the root of *T. clarkei* that may be able to prevent diabetes. The in vitro antioxidant activity of *T. clarkei* root (Chung *et al*., 2019) and inflorescence (Khatoon *et al*., 2018) extracts has also been reported. "Nakima" contains nutrients that are comparable to those found in popular plants like asparagus (Gurung *et al*., 2018). Because it is bitter, a lot of people don't like the taste. The blossoms are cooked like vegetables after being blanched to remove their bitterness. It is cooked with tomato, onion, garlic, ginger, and chilies and goes well with roti or rice. Due to the limited availability of flowers, some also prefer to pickle them in order to prolong their shelf life. Pickles are made by blanching flowers, letting them dry slightly in the sun or shade, and then adding oil. The shelf life of this pickle is one to two years. Local chilli dalley is often added to the pickle to improve its flavor. When making curries, the flowers are traditionally cleaned and blanched for around five minutes. According to Bhutia *et al*. (2023), the blanched flowers are cooked with tomato, onion, and chile before being drained and mixed with other vegetables. Traditional methods also involve producing dried nakima blossoms.

The medical properties of "nakima" are the reason for its current spike in popularity among consumers. There are numerous indigenous and traditional uses for the herb in medicine. Dried flowers and powdered root are combined to make a tonic that is useful to regulate diabetes and relieve body pain (Chettri *et al*., 2020a; Hussain and Hore 2007; Idrisi *et al*., 2010). Lepcha *et al*. (2019) reported that root decoction is used not only for food poisoning but also for rheumatic pain, insomnia, constipation, and urinary problems. In addition to being a fantastic source of secondary metabolites, flowers also make a tasty appetizer. According to Verma and Nath (2016), flowers may offer a naturally occurring antioxidant that could guard against oxidative stress-related degenerative illnesses. However, this vegetable should not be consumed by people who have low blood pressure or kidney problems. Chung *et al*. (2019) have proposed the use of root extract as a valuable bioresource for the food and pharmaceutical industries and authenticated its use in traditional medicine through the measurement of phenolic compounds, antioxidant and antimicrobial activity, and an inhibitory effect on α-glucosidase. Sikkim's hill dwellers are sufficiently knowledgeable of and used to organic farming. Although it is not widely used, it is one of the commercial crops of Sikkim and has a high probability of being included in diets worldwide.

Fig. 3. (d) Curry and **(e)** pickle prepared from nakima

Source: Chettri, 2020b;

Market potential of nakima

Thanks to its medicinal and antioxidant qualities, nakima is an essential component of traditional Himalayan cuisine. The majority of its growth occurs in natural settings, with a smaller amount occurring in domestic gardens. Farmers have been moving toward commercial farming in an effort to get a better price due to the market's growing demand. Because cross-cultural interactions and disease and pest management are not necessary, the growing techniques demand less work. According to Bhutia and Singh (2022) it is considered organically cultivated because no fertilizers are utilized during the cultivation process. People are also become more aware of the cost in addition to the product's nutritional and medicinal advantages. The marketing channel is critical for vegetable crops grown in mountainous terrain (Kumar *et al*., 2018). Compared to other seasonal veggies, this vegetable flower costs more. When the season begins in September, farmers earn anything from Rs 400 to Rs 500 per kilogram. In the capital city, prices rarely go below Rs 200 per kg, even during the busiest time of year (Bhutia *et al*., 2023).

Future Prospects

Nakima has great potential as a medical crop and as a crop for the future due to its high antioxidant content. Only present in a few locations in India, this native vegetable flower is now underutilized. Research on post-harvest handling is necessary to boost the appeal of this vegetable flower. Despite its many uses and the wealth of current research on its anti-inflammatory qualities, the post-harvest application of nakima has not been studied. Adopting suitable processing and preservation methods in addition to the scientific evidence proving the flowers' importance could be the first step toward nakima flowers' commercialization. Focus should be placed on producing food items with additional value, like powdered, frozen, and dehydrated nakima blossoms (Bhutia *et al.*, 2023). The marketable stage of inflorescence is short-lived (Bhutia and Singh, 2022). Pradheep *et al.* (2020) state that it would be crucial to develop a package of growing techniques, add value, research and validate its nutraceutical properties, and market it with the help of extension functionaries.

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ILLUMINATING THE FUTURE OF FARMING: HOW PHOTONICS IS REVOLUTIONIZING AGRICULTURE

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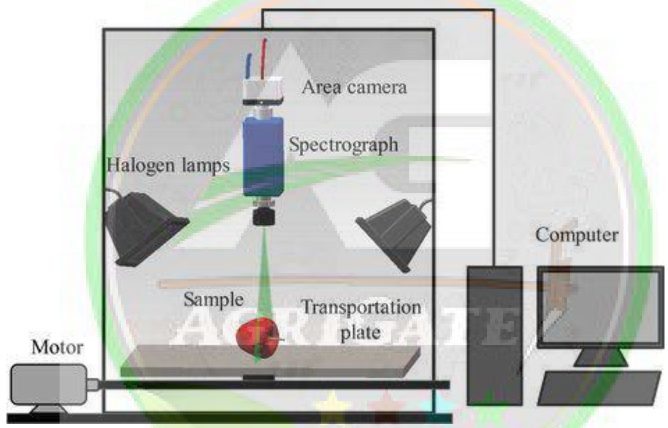
Introduction

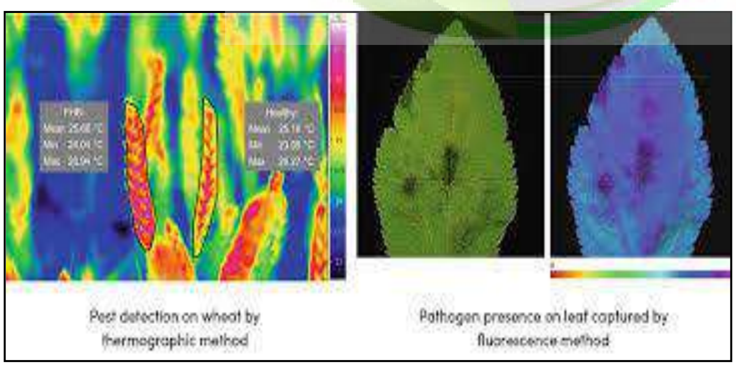
Technology has changed agriculture dramatically in the last few decades to increase efficiency, sustainability, and productivity. Among these developments, photonics has become a potent instrument that is changing the face of agriculture. Precision farming methods to remote sensing are just a few of the many uses for photonics, the science and technology of producing, detecting, and manipulating photons. Through the utilization of light-based technology, agricultural researchers and farmers can explore the finer points of crop health, soil properties, and environmental influences; this leads to better decision-making and more efficient use of resources. Agriculture is used to monitor crop growth, pest infestations, and water availability using manual observation and traditional methods. However, these methods frequently lacked the accuracy and promptness needed to deal with the ever-changing problems that modern farming faces. Here comes photonics, a revolutionary technology that uses the characteristics of light to deliver an abundance of data at a speed and accuracy never seen before. Photonics provides a comprehensive approach to monitoring and controlling agricultural systems, ranging from satellites with advanced imaging systems to ground-based sensors that measure minute changes in plant physiology.

Photonics Empowerment in The Realm of Smart Farming

One of the primary objectives of the Sustainable Development Goals, which were established by the UN in 2015, is to achieve Global Zero Hunger. To attain this, advancements in infrastructure and technology will be necessary to increase agricultural output. When it comes to the environmental impact of agriculture, the numbers speak for themselves. 24% of greenhouse gas emissions, 70% of the world's water use, and environmental damage are all attributable to agriculture. Increasing food production with the methods we now use is not sustainable. Another growing worry is food waste. During the harvesting, processing, distribution, or at the moment of consumption, one-third of all food produced is wasted. In this regard, photonics is contributing significantly to food production and consumption.

Hyperspectral cameras, for instance, can identify when fruits are ready to be picked and how mature they are. Fluorescence spectroscopy can track nutrients, vitamins, allergies, and other ingredients in meals at the consumption stage, while imaging and labeling offer faster food preparation.





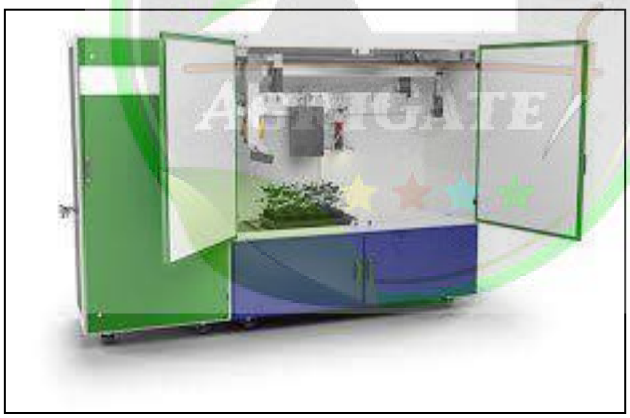
Sendosafe Sensor mounted Tractor to protect field animals from heavy agricultural equipment

Optical sensors are integrated into automation systems and heavy machinery by major corporations such as FESTO and John Deere. Notably, computerized systems based on optical sensors enable precise identification of insects. They can be included in pest management programs that include proactive treatments and clever spraying apparatus.

Similar to this, Optronia, a company based in Innsbruck, Austria, was created in 2018 and just released the Sendosafe Sensor to prevent field animals from dying in heavy agricultural equipment. Their sensors recognize wildlife and, when paired with AI and machine-vision cameras, automatically lift the cutting gear to keep the animal from getting hurt.

Another industry that now benefits from optical sensors is vertical farming, which is the practice of growing crops on top of one another as opposed to in conventional, horizontal rows. Photonic sensors are being used by businesses such as Agricola Moderna (Milan, Italy) to support and improve their automated control systems for data collecting, illness detection, and environmental control. They are also being used to help optimize operations and yield.

Hyperspectral imaging is a non-invasive, non-contact technique that offers sustainable, optimal instruments for agricultural production. The health and nutritional state of the plant can be used to inform crop management decisions by using hyperspectral imaging to measure nutrients including nitrogen, phosphorus, potassium, and flavonoids.



Plant Phenotyping System

To maximize crop management decision-making, hyperspectral imaging is also utilized in plant phenotyping. This technique collects data on the chemical assets, size, and shape of the plant. One Planet Research Center, IMEC, situated in the Netherlands, is a pioneer in revolutionary real-time sensing techniques (hyperspectral imaging, near-infrared [NIR] and Raman spectroscopy, and integrated photonics for agri-tech). The objective of One Planet is to enhance comprehension and refine food production.

Unlocking the Power of Light with the Potential of Photonics:

The science of using light for the good of humanity is known as photonics. Numerous applications are hidden under this definition. Light is three things: it's clean, precise, and speedy. Characteristics that make photonics an essential technology for addressing the forthcoming big issues in the sector of Technology include the following platform of tools.

Automation and robotics technologies:

Photonic sensors, such as lidars and cameras, are necessary for robots to move independently, investigate their surroundings, make choices, and carry out tasks of their own decision.

Imaging and sensors:

Since imaging is the process of capturing light, it is intrinsically photonic. Photonics is the sole means of executing sophisticated examinations without physical interaction. Photonics is the basis for the majority of sensors used in disease detection, soil and water analysis, crop, and fruit quality, and also the study of the crop's quality parameters with more precision.

Big Digitalization and Data Analysis:

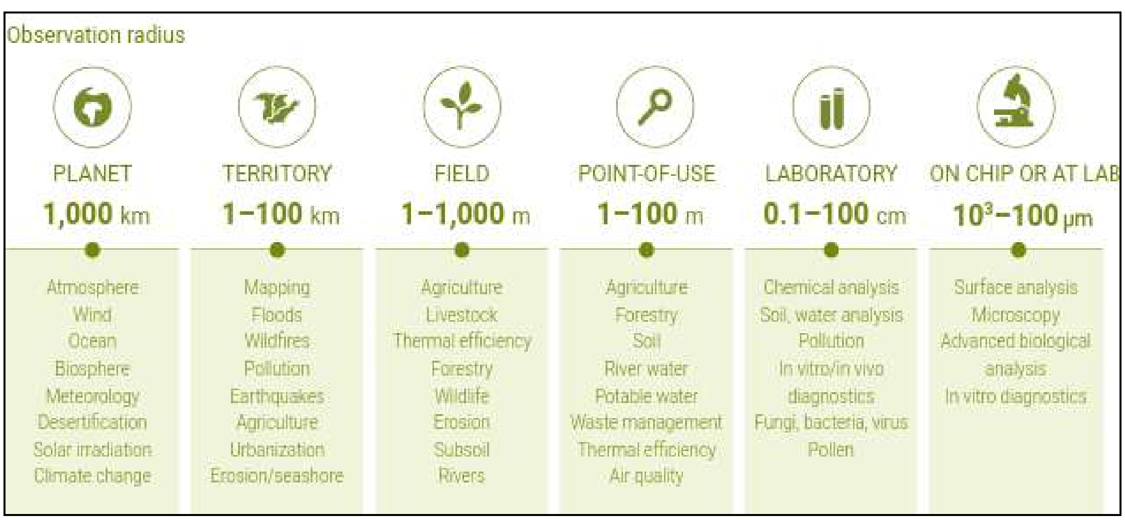
The core of telecommunications networks is fiber optics. Transceivers, or the parts that change light into electricity and vice versa, are essential to data centers' operation.

The field of bioengineering

Research in bioengineering and biotechnology mainly uses microscope methods. Without the use of photonic technology for PCR analysis, genetics would not be feasible. Advanced imaging is the foundation of phenotyping. The majority of scientific instruments are photonics-based.

Photonics Technologies Enable Precise Measurement of Complex Data Across All Scales:

Complex data may be measured at any scale, from the atom to the planet, thanks to photonics technologies. They are a special resource that aids in our comprehension and solutions to the environmental problems that agriculture faces.



Constraints in precision farming using photonics:

Photonics confronts four significant obstacles before being widely used in agriculture, and these need to be overcome with realism and humility for the sustainability of this technology.

- **Two universes colliding:**

Although the photonics community is quite creative in its problem-solving, photonics engineers are not farmers, and agronomists and farmers are not physicists. This indicates that to comprehend the complexities involved in raising animals or crops and convert this knowledge into suitable photonics parameters, a thorough consultation and some translation are required.

- **Livestock and crops have enormous diversity:**

More than 8,000 types of tomatoes, more than 10,000 varieties of apples, and more than 800 far cow races with meds! Every crop variety and animal race has unique characteristics, including size, color, physiology, disease, and pests. Every type of crop and every race of animal has evolved to a particular temperature and terrain. They're all going to generate or work well with a particular cuisine. Stated differently, the challenge lies not only in developing photonic sensors or equipment but also in making them sufficiently versatile to be effective and beneficial regardless of the types utilized and in allowing software to modify the working parameters. In this manner, the same hardware can be made at a reasonable cost and used on a big enough scale.

Usability is crucial:

The third challenge is creating cutting-edge machinery with high-tech parts that are simple enough for humans without a background in physics to operate. This is a really difficult task because working with living things requires working with complexity. Nonetheless, the onus of addressing the challenges lies on technology vendors.

- **A lot of farmers are not very good at making investments:**

Large farms that have the financial means to purchase cutting-edge equipment have been observed in the past, but there are also many tiny farms with far lower revenue. Larger farms have been and will continue to be the early adopters due to their greater financial capability as well as the fact that they often have more technological experience. Long-term, though, all farms—big or small—should have access to more sophisticated technologies that will increase their income while honoring their customs. There are two things at stake: feeding the world's population and solving sustainability issues.

Conclusion

A significant turning point in the development of farming methods has been reached with the introduction of photonics technology. Photonics has the potential to significantly improve precision, maximize resource use, and transform data collecting and analysis, making it a crucial tool for resolving today's sustainable agricultural issues. Using light to their advantage, farmers may handle complexity more skillfully, increasing yields, lessening their impact on the environment, and eventually building a more resilient and successful agricultural industry. The potential for revolutionary breakthroughs is still endless as we investigate and create at the nexus of photonics and agriculture, offering a more promising and sustainable future for global food supply. The merging of these two universes will take time. Undoubtedly, a promising future is in store for the agriculture industry as a growing number of photonics startups and companies make their way into it. Apart from the engagement between these participants and agriculture specialists, artificial intelligence and deep learning will introduce novel approaches to considerably more progressive and technically supportive in the future.

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AGRONOMIC INNOVATIONS FOR ENHANCING FARMERS' INCOME

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Abstract

Income, which refers to regular earnings from work or investments, is pivotal in sustaining livelihoods, especially in the agricultural sector, where farmers encounter numerous challenges. The resilience of farmers in the face of these challenges is evident in India's notable agricultural growth since 1947, recognised by NABARD. However, the volatility of farm incomes has led to waning interest and investment in farming, prompting many to abandon the profession altogether. In response, a concerted effort has been made to enhance farmers' income by 2022-23, as outlined by the Ministry of Agriculture and Farmers' Welfare. This endeavour involves various strategies, including accelerated growth, post-production process interventions, and agricultural marketing improvements. Sustainable crop and soil management practices have emerged as critical factors in achieving a consistent rise in farmers' income, with methods like zero tillage, mulching, and precision-based irrigation demonstrating notable effectiveness. Research findings highlight the economic advantages of such practices, showcasing substantial increases in net income across different crop types. These findings underscore the significance of sustainable management practices in augmenting farmers' income and ensuring the sustainability of agriculture as a viable livelihood.

Keywords: crop management; profit; agrarian economy, income

Introduction

The concept of income, denoting the consistent monetary gains derived from labour or investments, underscores the steadfastness of farmers who have been pivotal in driving substantial agricultural progress since 1947. However, despite their unwavering commitment, farmers face formidable challenges. Despite possessing valuable land assets, many farmers grapple with impoverished conditions, with an average household income of ₹6,426 and monthly expenditures amounting to ₹6,223, leaving 22.50% below the poverty threshold. This paradox arises from the uncertainties inherent in both production and market dynamics. To ensure the flourishing of agriculture, sustained growth is imperative, contingent upon favourable net returns from the agricultural enterprise, which, in turn, facilitate savings and investments.

Enhancing Farmers Income

The traditional focus of agricultural development in India has primarily centred on increasing output and ensuring food security, often overlooking the critical aspect of augmenting farmers' income. This oversight has resulted in consistently low and unpredictable earnings for farmers, leading to disillusionment among many, particularly the younger generation of farmers, with the agricultural sector. Acknowledging the pivotal role of farmers' income in ensuring agricultural sustainability and rural prosperity, the Prime Minister articulated a vision to boost farmers' earnings during a speech in Bareilly in February 2016. A timeline spanning six years, from 2016-17 to 2022-23, was delineated to implement this new strategy, underscoring the pressing need and significance of prioritising farmers' welfare and income growth in agricultural policies.

Challenges in Agriculture

Farmers encounter numerous obstacles that affect their profitability and sustainability, as highlighted by NABARD in 2019. These challenges encompass a range of issues such as natural calamities like floods, droughts, and hailstorms, delays in crop sowing, high expenses and limited accessibility of hybrid seeds, insufficient availability of short-duration high-yielding varieties, escalating production costs, inadequate storage and processing facilities, market instabilities, excessive reliance on chemical fertilisers and pesticides leading to environmental degradation, below-average crop yields compared to national standards, deficient marketing infrastructure, declining groundwater levels, farmers' lack of knowledge, and mounting concerns regarding ecological contamination and malnutrition. Overcoming these obstacles necessitates implementing comprehensive strategies to bolster the agricultural sector's resilience and promote farmers' welfare.

Pathway to Enhance Farmers' Income

A comprehensive approach, as endorsed by MoA and FW in 2019, is essential for addressing agricultural challenges thoroughly. This involves understanding historical, current, and future agrarian dynamics, accelerating farmers' income growth, improving post-production logistics, tackling sustainability issues, and enhancing productivity through effective input management. Initiatives like the DFI, which originated in 1926 with the Royal Commission of Agriculture, aim to achieve sustainability and profitability in agriculture by reinforcing extension policies and acknowledging agriculture as a business. Despite initial growth trends, declines in agricultural exports since 2014 have impeded sectoral progress, leading to low net income and growth rates from farming activities, particularly impacting rural areas. Strategies such as diversifying crops with high value and reducing post-harvest losses are recommended to ensure profitability in farming, with a targeted growth rate of 67 per cent required. Logistics, central to the DFI, are crucial in minimising food losses and waste, facilitating efficient food distribution, and meeting consumer demand. Furthermore, the DFI emphasises maximising income from each crop unit, advocating for equitable agricultural marketing practices, digitising national agrarian markets, and promoting sustainable farming techniques like soil carbon management and conservation agriculture. Enhancing resource efficiency, integrating newer insecticides, reinforcing extension services, and embracing sustainable crop and soil management practices are also pivotal for achieving consistent income growth and ensuring agricultural sustainability.

Crop Management Practices for Improving Farmer's Income

Rainwater harvesting structures

The practice of water harvesting entails the collection of runoff for productive use, erosion prevention, and efficient water utilisation. Particularly advantageous in semi-arid and drought-prone regions, it is an effective soil and water conservation method, leading to significant yield improvements and production reliability. A research study conducted in the Koppal and Gulbarga districts of North Karnataka evaluated the impact of rainwater harvesting structures (RWHS), such as farm ponds and recharge pits, on various agricultural parameters. Farmers who invested in RWHS witnessed notable increases in cropped area, cropping intensity, irrigation intensity, and income across different crops. The additional net income generated ranged from 713 to 2,041 rupees per crop, with percentage increases in income ranging from

17.06% to 87.56%, underscoring the substantial benefits of rainwater harvesting for farmers (Badiger et al., 2016).

Precision Mobile Drip Irrigation

A study conducted over a span of two years, from 2015 to 2016, compared the grain yields, crop water utilisation, and water utilisation efficiency of corn under different irrigation methods, namely mobile drip irrigation (MDI), low energy precision application (LEPA), and low elevation spray application (LESA). MDI involves adapting drip lines to mobile sprinkler systems, delivering water directly to the soil surface as the lines traverse the field. Irrigation levels were adjusted based on weekly readings from neutron probes. Grain yield and yield components exhibited similar patterns across all methods in both years. While water utilisation efficiency showed no significant differences between MDI, LEPA, and LESA during the wet 2015 season, MDI demonstrated enhanced water utilisation efficiency during the drier 2016 season. (O'Shaughnessy and Colaizzi, 2017).

Drip Irrigation

Drip irrigation, a type of micro-irrigation, conserves water and nutrients by delivering water slowly and directly to plant roots, thus minimising evaporation. Another approach, Alternate Wetting and Drying (AWD), conserves water in lowland rice cultivation by implementing controlled, intermittent irrigation, reducing water demand and greenhouse gas emissions without compromising yields. Although relatively recent in India, drip irrigation has shown significant water savings and improvements in crop productivity, especially in high-value fruit crops. However, more research is needed on its economic and resource impacts, particularly on crops like okra. A study conducted in a water-scarce district of Tamil Nadu revealed that drip irrigation reduces weed growth, thereby reducing labour requirements and cultivation costs for okra. Overall, drip irrigation holds promise for lowering cultivation costs and enhancing productivity in crops like okra compared to flood irrigation methods.

With labour, water shortages, and concerns about the adverse effects of puddled soil health, farmers are shifting from puddled transplant to alternative rice production systems. A research project conducted from 2013 to 2015 at the Agricultural Engineering College and Research Institute in Kumulur, Trichy District, aimed to improve water management in mechanised dry-seeded rice cultivation during the Samba season. The study found that employing the alternate wetting and drying (AWD) irrigation method, combined with specific fertilisation (120:50:50 NPK kg ha-1), pretilachlor weed management, and two machine weddings, resulted in the highest establishment percentage, optimal productive tillers, highest grain yield (8.16 t ha-1), net income (74,477 Rs ha-1), benefit-cost ratio (3.80), and the highest water use efficiency (0.58 kg ha-1 mm-1) (Kannan, 2016).

Mobile Application-Based Irrigation Scheduling

The Phule Jal App and Phule Irrigation Scheduler, created by MPKV Rahuri, provide indispensable support to farmers. The application calculates evapotranspiration at designated sites by retrieving up-to-date weather data from service providers. Farmers need to interpret this evapotranspiration data accurately, determining exact water application quantities and timings customised to particular crop varieties, soil conditions, irrigation methods, weather forecasts, and geographical locations.

Mechanisation

Agricultural mechanisation entails the utilisation of diverse power sources and advanced equipment to diminish reliance on human and animal labour, intensify cropping frequency, enhance precision, and optimise the efficient use of crop inputs while reducing losses across various stages of crop production. Its primary objective is to augment overall productivity and output while minimising operational expenses. Mechanisation is pivotal in tasks such as seed sowing, irrigation, and applying chemical inputs. A study conducted at KVK, Tirupati, compared manual transplanting with machine transplanter techniques, revealing that manual methods decreased labour requirements and cultivation expenses. In contrast, a transplanter ensured uniform plant spacing, reducing intra-plant competition and increasing grain yields. Consequently, there was a significant improvement in net returns (Sreenivasulu and Reddy, 2014).

Fertilizer Briquette machine

The Fertilizer Briquette machine operates on the principle of Dry Compression, producing pillow-shaped briquettes composed of a mixture of Urea and DAP. Distinct Horizon's patented DH Vriddhi tool assists farmers in embedding fertilisers deep into the soil through the Urea Deep Placement (UDP) technique, thereby minimising excessive fertiliser usage and enhancing crop productivity (Reddy, 2020).

Crop Establishment Methods

The critical significance of soil in fostering crop establishment and growth is frequently overlooked despite its indispensable role. Issues with soil structure can impede root development, nutrient absorption, and moisture retention, with compaction presenting a particularly insidious challenge for maise cultivation. Robust root systems empower plants to endure environmental stressors, such as extended periods of drought, underscoring the necessity of employing appropriate crop establishment practices. A study examining various rice establishment methods in puddled conditions revealed that the drum seeder technique proved economically viable and more lucrative than alternative approaches (Visalakshi and Sireesha, 2013).

Aerobic Rice Production

Aerobic rice farming involves cultivating specially bred varieties in well-drained, non-puddled soils to achieve yields ranging from 4 to 6 tons per hectare. The preferred establishment method is dry direct seeding, which enables adopting conservation agriculture techniques such as mulching and minimal tillage. Unlike traditional flooded rice cultivation, aerobic rice can be sustained through rainfed conditions or irrigation methods such as flash-flooding, furrow irrigation, or sprinklers. In Punjab, transitioning to direct rice sowing led to a 34% reduction in water usage and associated costs. A comparative study conducted in Karnataka's South Dry Zone found that aerobic farming systems yielded higher gross and net incomes than conventional methods, highlighting the economic viability of aerobic rice cultivation (Sreenivasa et al., 2016).

Cropping / Farming Systems

Utilising a farming systems approach within micro-watershed-based agricultural diversification presents an opportunity to optimise water, nutrients, and energy use while also integrating nutrient management effectively. The primary objective is to enhance farm production and income stability while minimising pollution through waste recycling across different agricultural activities. Multi-enterprise farming systems mitigate risks, generate employment opportunities, and contribute to sustained or increased household income. Customised diversification models are particularly crucial for small and marginal farmers to ensure the sustainability of rural livelihoods. A case in point is a model farming system developed by CRIDA for smallholders on Alfisols, which demonstrated superior economic efficiency compared to traditional cropping systems, with various enterprises collectively contributing to overall net income (Panwar et al., 2018).

Mulching

Mulching, which involves covering soil to improve plant growth and enhance crop production, also minimises evaporation and inhibits weed growth. Trials conducted in the Dzongu Valley of North Sikkim highlighted the efficacy of Schima wallichii leaves as a bio-mulch for ginger farming, resulting in elevated yields and income levels. The utilisation of Schima wallichii mulch exhibited superior advantages and cost-effectiveness compared to alternative treatments, primarily attributable to its higher yield outcomes (Kumar et al., 2012).

Foliar Application of Nutrients/Growth Regulators

The application of nutrients and growth regulators via foliar spraying is suggested to improve fertiliser utilisation efficiency by facilitating rapid absorption of nutrients and prompt correction of deficiencies, in contrast to conventional soil treatments. In regions characterised by low pulse crop productivity due to sandy soils with inadequate water and nutrient retention capabilities, a study conducted at the Agricultural Research Station in Tamil Nadu examined the effects of various phosphorus sources (mono- and diammonium phosphate) combined with brassinolide and salicylic acid on the growth and yield of black gram in sandy loam soils. The research revealed that the application of the total recommended dose of NPK fertiliser, supplemented with 2% DAP and TNAU pulse wonder at a rate of 5.0 kg/ha, administered 45 days after sowing, could effectively exploit the genetic potential of black gram, leading to increased productivity and profitability in the Cauvery Delta Zone of Tamil Nadu, India (Marimuthu and Surendran, 2015).

Conclusion

Agricultural methodologies, including rainwater harvesting, precision mobile drip irrigation, and traditional drip irrigation, contribute to farming practices' financial viability and sustainability. Rainwater harvesting enhances crop yields and production reliability in semi-arid regions while conserving water resources. Precision mobile drip irrigation improves water utilisation, particularly in arid conditions, increasing crop output. Drip irrigation conserves water and nutrients, reducing cultivation expenses and enhancing productivity, as observed in crops like okra. Agricultural mechanisation decreases labour and cultivation costs, leading to higher profitability. Furthermore, technologies like fertiliser briquette machines and foliar nutrient application further enhance crop productivity and profitability. Aerobic rice production, mulching, and diversified farming systems also stabilise farm income and promote sustainability. These strategies facilitate efficient resource management and productivity enhancements, supporting farmers' livelihoods and ensuring the sustainability of agricultural practices (Adarsh and Ameena, 2021).

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THE ECOLOGICAL INFLUENCE OF EXOTIC FISH SPECIES IN INDIA

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Abstract

Over the past decade, there have been numerous instances of invasive exotic fish species introduced India, which have had adverse effects on indigenous fish biodiversity. The depletion of freshwater aquatic biodiversity has reached alarming levels, largely due to the introduction of exotic species and other human-induced activities. The indiscriminate transfer of exotic fishes has resulted in a multitude of problems, including the extinction of indigenous species. These exotic species compete with native species for food and habitat, and may even prey upon them, introduce new parasites and diseases, lead to hybridization, and contribute to the genetic degradation of indigenous species. Furthermore, they also contribute to the degradation of the physico-chemical characteristics of aquatic ecosystems.

Keywords: Exotic species, Introduction, alarming level, aquatic ecosystem

Introduction

The global aquatic biodiversity is rapidly declining due to a variety of factors such as habitat destruction, pollution, the introduction of non-native species, overexploitation, and other human-induced activities (Moyle & Moyle, 1995). This depletion is particularly severe in freshwater ecosystems, which account for only 0.1 percent of the Earth's water resources but support 40 percent of known fish species (Nelson, 1994). Fish serve as keystone species in ecosystems, influencing the distribution and abundance of other organisms within their habitats, while also serving as reliable indicators of water quality and ecosystem health. Alarmingly, approximately 20 percent of the world's freshwater fish species have already become extinct or are teetering on the brink of extinction (Moyle & Leidy, 1992). Organisms that coexist harmoniously within one habitat may become highly disruptive when introduced into another. When a species is introduced to an environment where it has not historically existed, predicting its impact on native flora and fauna becomes extremely challenging.

Introduced species often outcompete indigenous species for space and resources, as they may lack natural predators in the new area. In some cases, introduced species may directly prey on and consume native populations, disrupting intricate webs of interdependence that have evolved over millennia. An introduced species, also known as an exotic species, refers to any organism intentionally or accidentally transported and released outside its native range by human activity (Kottelat and Whitten, 1996). The International Union for Conservation of Nature and Natural Resources (IUCN) defines Alien Invasive Species as non-native species that establish themselves in natural or semi-natural ecosystems or habitats, acting as agents of change and posing threats to native biological diversity. These invasive species are prevalent in various ecosystems worldwide and encompass all categories of living organisms (Raghubanshi et al., 2005).

Exotic fish species have been introduced to numerous regions around the globe for a variety of purposes (Biju Kumar, 2000), including:

1. Enhancing local fishery potential and increasing species diversity in aquatic systems.
2. Facilitating sport fishing activities.
3. Meeting demand for aquarium keeping.
4. Managing unwanted organisms such as mosquitoes.

The uncontrolled movement of aquatic organisms, especially fish, has sparked global apprehension due to its various detrimental effects, including the elimination of native species. Exotic species often compete with indigenous fish for food and habitat, posing threats such as predation, introduction of diseases and parasites, hybridization, and genetic dilution of native species. Additionally, they contribute to the degradation of the physical and chemical characteristics of aquatic ecosystems. These cumulative impacts ultimately result in biodiversity loss (Nyman, 1991).

Welcome (1988) reported that 168 fish species from 37 families had been introduced beyond their natural distribution ranges worldwide. Of these, at least 67 species successfully established populations in various water bodies, with 27 species proving to be significant pests. Experts further emphasize the need for caution in transferring fish to different habitats within the same country, advocating for measures similar to those taken for transboundary introductions (Kottelat & Whitten, 1996).

Introduction of Exotic Fish Species in India

Over the past few decades, India has witnessed the introduction of over 300 exotic fish species for various purposes such as experimental aquaculture, sport fishing, mosquito control, and aquarium keeping. Additionally, a mollusc species (*Mytilopsis sallei*) native to Central America has been introduced to Indian waters, likely through ship fouling, along with several invasive aquatic weeds (*Eichornia crassipes*, *Salvinia molesta*, *Pistia stratioides*, and *Ipomea carnia*) from tropical South America. There have also been reports of clandestine introductions of hazardous fish species. Table 1 provides a list detailing the important fish species introduced to Indian waters, their country of origin, and the date and purpose of their introduction. Many exotic fish species have now established populations in natural water bodies across India. While limited studies have been conducted on the impacts of exotic species in Indian waters, reports from other regions unequivocally demonstrate the devastating effects of species like Tilapia, Silver Carp, Gambusia, and Common Carp on aquatic ecosystems.

Table 1: **list of some exotic fish species that have been introduced into Indian waters**

Species	Home country	Year	Purpose
Game fishes			
Brown Trout (*Salmo trutta fario*)	U. K	1863-1900	For planting streams, lakes and reservoirs
Loch Leven Trout (*Salmo levensis*)	U. K	1863	For planting streams, lakes and reservoirs
Rainbow Trout (*Salmo gairdneri*)	Sri Lanka & Germany	1907	For planting streams, lakes and reservoirs
Eastern Brook Trout (*Salvelinus fontinalis*)	U.K.	1911	For planting streams, lakes and reservoirs

Sockeye Salmon (*Oncorhynchus nerka*)	Japan	1968	For planting streams, lakes and reservoirs
Atlantic Salmon (*Salmo salar*)	U.S.A.	1968	For planting streams, lakes and reservoirs
Food fishes			
Golden Carp (*Carassius carassius*)	U.K.	1870	Experimental culture
Tench (*Tinca tinca*)	U.K.	1870	Experimental culture
Gourami (*Osphronemus goramy*)	Java & Mauritius	1916	Experimental culture
Common Carp (*Cyprinus carpio*)	Sri Lanka	1939	Experimental culture
Tilapia (*Oreochromis mossambicus*)	Africa	1952	Experimental culture
Common Carp (*Cyprinus carpio*)	Japan	1957	Experimental culture
Grass Carp (*Ctenopahryngodon idella*)	Hong Kong	1957	Experimental culture
Silver Carp (*Hypophthalmichthys molitrix*	Indonesia	1959	Experimental culture
Tawes (*Puntius javanicus*)	Indonesia	1972	Experimental culture
Larvicidal fishes			
Guppy (*Poecilia reticulata*)	South America	1908	Mosquito control
Top Minnow (*Gambusia affinis*)	Italy	1928	Mosquito control
Ornamental fishes			
Live bearers (27 species)	From various countries		Aquarium keeping
Egg layers (261 speceis)	From various countries		Aquarium keeping
Unauthorised introductions			
Bighead Carp (*Aristichthys nobilis*)			Aquaculture
African Catfish (*Clarias gariepinus*)			Aquaculture
Nile Tilapia (*Oreochromis niloticus*)			Aquaculture

Red Tilapia (*Oreochromis* sp.)	Aquaculture
Red Piranha (*Serrasalmus nattereri*)	Aquaculture keeping

Fig1: Some of the exotic fish species

The Ecological Effects of Exotic Fish Species in India

1. The introduction of silver carp into the Govind sagar reservoir in Himachal Pradesh has led to the drastic decline of the previously abundant native Indian major carp population. The reservoir, situated on the river Sutlej and spanning approximately 10,000 hectares, is now overwhelmingly dominated by invasive silver carp. Currently, the reservoir's fauna primarily consists of silver carp, comprising around 60-65% of the total catch, followed by Indian major carps at 20-25%, mahseer species at 8-10%, and minor carps at 8-10%.

2. The introduction of common carp into the Ganga River system has resulted in its domination, accounting for approximately 20% of the total fish population. Common carp is recognized as a nuisance species due to its significant adverse impacts on various aquatic ecosystems. This species feeds by browsing on submerged vegetation, uprooting plants essential for the habitat and food of other aquatic species. Consequently, it muddies the waters and disrupts the food and cover needed by other fish.
3. The introduction of Thai magur or African catfish *Clarias gariepinus* into Indian waters presents a significant threat to the country's native fish fauna. This species is not only aggressive but also highly predatory, posing a serious risk to India's wildlife and natural resources. Despite being banned by the Government of India, clandestine cultivation and sale of *C. gariepinus* continue on a large scale. Opportunistic and greedy farmers across the country are extensively breeding and cultivating this fish. The seeds of *C. gariepinus* are readily available in private hatcheries, particularly in West Bengal. There are reports of this fish already infiltrating many major rivers and reservoirs in India. If these reports are accurate, the consequences for native fish populations could be disastrous. The warning bells for India's native fish fauna are already sounding.
4. The introduction of the carnivorous and voracious Chinese bighead carp (*Aristichthys nobilis*) in the eastern and northeastern parts of India is a matter of significant concern. Should this exotic fish establish itself in natural water bodies, it could pose a serious threat to smaller indigenous fish species and invertebrates.
5. The introduction of the mosquito fish *Gambusia affinis* in India was initially intended as a tool to control the growing malaria problem, as it feeds on mosquito larvae. However, it has been observed that this fish is also causing serious ecological imbalances due to its voracious feeding habits. Due to its prolific breeding and voracious nature, Gambusia has earned the label of 'fish destroyer' (Myers, 1965). The Health Department, responsible for introducing this fish into rural ponds, should explore the possibility of introducing native minnows and perches with similar feeding habits instead of relying on the alien mosquito fish. It's worth noting that Indian fishes such as *Macropodus* and *Aplochielus* have shown effectiveness in mosquito control and should be considered for implementation.
6. Previously, the introduction of sport fishes in Indian waters was regarded as non-problematic (Shetty et al., 1989). However, trouts have been observed to compete with native stocks,

resulting in their decline, and in some cases, hybridization with genetically similar indigenous species (Rinne, 1995). Notably, introduced sport fishes like Rainbow Trout have been identified as significant predators on the eggs and juveniles of native species (Blinn et al., 1993). These findings underscore the need for further investigations into the impact of introduced sport fishes in Indian waters.

Conservation of aquatic biodiversity

Stringent regulations should be established regarding the importation of non-native fishes, given their negative impact on aquatic biodiversity. According to regulations, exotic fish varieties must receive clearance from the National Committee on Introduction of Aquatic Species in Indian Waters, New Delhi before introduction. This committee, consisting of the fisheries development commissioner and experts, evaluates the relevance of importation and assesses the potential impact of the new species on the Indian aquatic environment. However, illicit importation and trade of exotic fishes persist, particularly of carnivorous aquarium fish like piranha, due to inadequate enforcement of laws and lack of political will. The situation calls for a revision of existing laws and procedures for implementation. A code of practice, preferably following the guidelines of de Silva (1989), the European Inland Fisheries Advisory Commission (EIFAC), and the International Council for the Exploration of the Sea (ICES), should be adopted to minimize the risk of species introduction. Additionally, stringent quarantine standards should be mandated for the importation of aquatic organisms.

Conclusion

India stands out as one of the world's most biodiverse countries in terms of freshwater fish species. In the realm of freshwater fish diversity, India ranks eighth globally and third in Asia. Given the abundance of culturable species, further introduction of exotic fish species is deemed unnecessary. However, the trade in aquarium fish and the introduction of fish for aquaculture purposes are expected to rise in the future. Therefore, effective quarantine measures are imperative to prevent adverse impacts and the introduction of exotic pathogens and parasites along with introduced species. A comprehensive plan and guidelines have been devised to regulate fish introduction in India. Additionally, detailed species-specific guidelines have been developed for the introduction exotic species in India. These guidelines have been submitted to the Department of Animal Husbandry, Dairying, and Fisheries (DAHD&F), Ministry of Agriculture, New Delhi, for implementation and monitoring. It is expected that all farmers and fish breeders adhere to the prescribed quarantine guidelines developed by this institute to mitigate economic losses stemming from unplanned and indiscriminate introductions of exotic fishes.

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REVIEW ON TICK INFESTATION IN CATTLE – IMPACT, TREATMENT AND ITS CONTROL

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Introduction

Tick are common temporary external parasites of cattle. Tick infestation and Tick Borne Diseases (TBDs) are common conditions faced by the veterinarian in the field. Naturally indigenous cattle (*Bos indicus*) are relatively resistant to infestation compared to exotic cattle (*Bos taurus*) and cross breds, but due to the increase in trend of cross breeding in dairy industry there is drastic increase in the incidence of infestation and TBDs especially in the cross breed cattle.

Key words: Cattle, Tick infestation, Economy.

Epidemiology

The wild animal that act as reservoir of these arthropods. The epidemiological determinants like high temperature, humidity, moderate rainfall, adequate water sources aggravate the surplus tick population. Meteorological factors affect tick population dynamics via faster developmental rates with increasing humidity, and lower survival with extreme temperatures and low moisture and by negatively affecting individual reproductive behaviours. Meteorological factors might affect insect tick populations directly, through influences on reproductive and mortality ratios, and indirectly, through influences on their natural enemies. Seasonal variation in weather variables, such as rainfall and temperature maxima and minima, might be the most important causes of dramatic changes in tick abundance, especially in temperate ecosystems. Although the climate of tropical forest ecosystems is moderately constant (e.g., minimal variation in monthly average temperatures), marked local variation in temperature and precipitation might occur due to changes in topography, and such variation might affect tick population dynamics. The relationship between climate variables and tick abundance can provide important information to determine parasite activity levels and, therefore, disease risk. Exact information on the seasonal prevalence of tick fauna in a region is essential for the development of efficient vector control programs. But there were few published data on the seasonal abundance of ticks in India. (*Sachin Kumar, et al*.)

Key points

- Prevalence is very high in tropical countries like India (hot and humid conditions).
- Season and climate plays a key role in their epidemiological pattern.
- Global climate change and increase in the earth temperature favours their survival.

Types

1) One-host ticks

One-host ticks parasitize large hosts, mainly bovines and equines. Once the larva finds a suitable host, feeding and moulting proceed sequentially on the same host until the adult stage is reached. After feeding and mating, engorged adult females drop to the ground to oviposit.

Evolution of the one-host cycle has allowed tick species to survive in very harsh environments, since they are protected by the host for most of their life-cycle. This type of life-cycle is characteristic of *Boophilus* spp.

2) Two-host ticks

In these species, the larval and nymphal stages are spent on the same animal, but the nymph drops off to moult to the adult stage, which then seeks a final host. A few species in the genera *Hyalomma* and *Rhipicephalus*, typically in regions with long dry or cold seasons, and irregularly available hosts, have a 2-host life-cycle.

3) Three-host ticks

In these species, the larvae, nymphs, and adult females all feed on different host individuals. Larvae and nymphs detach and fall to the ground before moulting to the next stage and searching for a new host. Larvae and nymphs of most species feed on small mammals (rodents) or birds, while adults prefer larger hosts. The life-cycle of the tick affects the way in which acaricides are used: since one-host ticks stay on the animal longer than do 2- or 3-host species, the interval between dipping or spraying can be much longer for the former than for the latter. (*Minjauw, B. and McLeod, A.)*

Impacts

Ticks directly or indirectly shows their negative impact/effects on cattle

Direct effects –

Once ticks attach themselves to the cattle, they suck the host blood and continuously propagate. Amount of blood they suck from their host varies from 0.5ml to 2ml in a day. Continuous sucking of blood from the host leads to decrease in circulating blood volume and anaemia which further leads to alteration of physiology of host and even death.

It can therefore be realised how much quantity of blood can be lost per day by an animal infested heavily with ticks. An estimate of killing a calf by the attack of 500 *Boophilus* is understood. (Bhatia B. B., 2004).

When tick bites, there is local inflammatory response, loss in skin contour which causes localized dermatitis and sometimes secondary bacterial infection can also occur. Following the bite, blood oozing from the site can attract flies to settle and leads to myiasis or may mechanically transmit some disease causing pathogens. In leather industry – bite marks and local damage to the skin will deteriorate the quality of skin, which is a huge economic loss.

Infestation of ticks is stressful to the animals and continuous bites can make animal restless. Overtime infestation can retard animal's physiological functions causing stunted growth, immunosuppression, anestrum, infertility, failure in reaching peak of their economic traits like milk production, etc.

Tick paralysis (seen in calves).

Tick toxicosis is distinct from tick paralysis. It is produced by the toxins derived from one species of ticks. Tick toxicosis affects the cattle, sheep, goat and pig and is at its highest incidence in summer months. This condition occurs in animals in India and is chefly concerned with *Hyalomma truncatum* and other species of genus *Hyalomma*. The animal exhibits profuse moist eczema and hyperaemia of mucus membrane. It is mainly found I young animals and may lead to mortality. (Bhatia B. B., 2004).

Indirect effects

Ticks are potential vectors (biological) for many protozoal diseases like Theileriosis, Babesiosis, Anaplasmosis, Lyme disease, heart water disease and other parasitic diseases like spirocahetosis etc. called as tick borne diseases (TBDs). Each individual disease has its own pathology and negative effects on cattle. In common most of this haem protozoan diseases shows severe pyrexia, anaemia (mainly due to RBC lysis), debility, weakness, Inanition, multi organ failure (Ex// haemoglobinuric nephropathy) and death.

The major tick-borne diseases of cattle can be classified into four groups according to the vector species (McCosker, 1979):

1) ***Boophilus* spp.** are responsible for the transmission of species of Babesia (protozoa) and Anaplasma (rickettsia). World-wide, anaplasmosis and babesiosis constitute the most widely distributed TBD complex. They have a particularly severe effect on imported (exotic) highgrade dairy and beef cattle.
2) ***Hyalomma* spp.** are responsible for the transmission of the protozoan *Theileria annulata*, which causes tropical theileriosis. The latter occurs mainly in areas beyond the geographical focus of this report, but is present in India, where it mainly affects exotic cross-bred animals belonging to smallholders and peri-urban dairy producers; local cattle breeds and buffalo are much more resistant.
3) ***Amblyomma* spp**. are responsible for the transmission of the rickettsia *Cowdria ruminantium*, which causes Heartwater, a fatal disease which affects mainly sheep and goats, but also exotic cattle, throughout sub-Saharan Africa. *Amblyomma* spp. also transmit the protozoan *Theileria mutans* and facilitate the introduction of the actinomycete *Dermatophilus congolensis*, which is responsible for significant losses in West Africa.
4) ***Rhipicephalus* spp.** Are responsible for transmitting the protozoan *Theileria parva*, which causes East Coast fever (ECF), a devastating disease in eastern, central and southern Africa which is responsible for major losses in both small- and large-scale production systems.

Economic impacts of ticks on dairy business and farmers

Financial losses due to use of capital money directly in tick control, treatment costs for both tick infestation and Tick borne diseases or complete loss of money due to death of cattle. Indirectly due to low productivity and performance, poor reproductive health and thereby low returns. Now a day's problem of ticks acquiring resistance to the ectoparasiticides is increasing the cost of treatment and keeping additional burden on farmers

Treatment

Macrolytic lactones like Ivermectin and doramectin are commonly used for treatment of tick infestation. Ivermectin can be administered Sub cutaneous @0.2 mg/kg or pour-on are commercially available for topical use.

Insecticides (External applicators, should be used after diluting in water and applied externally/by dipping),

- Pyrethroids as pour-on, shampoos (not commonly used in cattle) and soaps. Common pyrethroids are permethrin (mainly soaps, sprays), cypermethrin (powders or liquid – to be diluted in water) and flumethrin (pour-on @1ml/10kg B.W)
- Organophosphates – Malathion (dips/sprays) and Organochlorides – lindane etc., but use of this 2 types of insecticides are uncommon these days. Amitraz is also a common insecticide can be used.

Care should be taken that these insecticides should not be applied directly on open wounds and prevent the animal to lick or consume them. Farmer or the person who's applying should be cautious and personal protection should be taken care of and should not get in contact with the sensitive areas like eyes etc.

Ethnoveterinary approaches like application of neem paste or neem oil externally can repel the ticks, it is highly beneficial especially for calves with minimal infestation. Hand picking and removing of ticks can be done only if few engorged ticks were noticed, but in heavy infestation this method is not practical.

Tick borne diseases should be diagnosed and specifically treated

Control

- Continuous monitoring of animals and checking for evidence of infestation
- Stall feeding of animals or rotational grazing can decrease the chances of infestation in the areas which prevalence of ticks in pastures is very high. (Burning of such pastures are not advised, it can pollute the environment).
- Insecticides application in pastures (movement of the animals should be restricted due to chances of exposure to toxicants).
- Shed and surroundings of the farm should be well maintained and surrounding bushes and weeds should be continuously chopped.

- Sealing of cracks and broken edges of walls as they are the common places where ticks hide when they are not attached to animals
- Integrated pest management programmes.
- Anti-tick vaccines (not common in India)
- Biological control –

Among biological agents, entomopathogenic fungi played a uniquely important role in the history of microbial control of insects. *Beauveria bassiana*, commoniy known as white muscardine fungus, attacks a wide range of immature and adult insects. *Metarhizium anisopliae*, a green muscardine fungus was reported to infect 200 species of insects and arthropods. Both these entomopathogenic fungi are widely distributed and are sail inhabiting. Entomopathogenic fungi were used successfully to control various agricultural and pasture pests. However, evaluation of their control potential for vectors of animal diseases has begun only recently. (Lalitha John *et al.*)

Other biological agents – entomopathogenic nematodes (Ex// family - Heterorhabitidae), bacteria like *Bacillus thuringiensis* etc.

Conclusion

Tick infestation is not only stressful and devastating to cattle but also for farmers (due to their direct or indirect impact on returns and economy). Public education and awareness is very essential especially about tick borne diseases. Recent increase in the resistance of multiple drugs and chemicals that are commonly used in treatment, multidrug or ethnoveterinary approaches are very much needed to tackle these situations.

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BARNYARD MILLET: HEALTH BENEFITS AND NUTRITIONAL VALUE

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Introduction

The millennial generation supports the revolt against unhealthy eating and is worried about how it will affect the environment and their health. Owing to their various benefits, traditional millets have returned to family use and are quickly vying for this compiler's affection. A common cereal or coarse grain with excellent nutritional content, adaptability, and accessibility is barnyard millet.

India's Uttarakhand state is home to the tiny, white-shaped barnyard millet seed. It has a higher nutritional content than other cereal grains and is an excellent source of fiber, carbohydrates, and protein. This can be given to infants older than a year old as dosa and idlis, or as gruel or kheer for newborns 6 to 8 months old. Though cooked, it tastes somewhat like rice, which is why it is known as "Sanwa Rice." When it comes to the daily meal and inactivity, which can result in a variety of health problems, Barnyard Millet is a true natural godsend.

Barnyard millet, also known as odalu in Telugu, Jhangora in Hindi, Kavadapullu in Malayalam, and Kuthiravali in Tamil, is a high-fiber grain. This millet has the lowest calorie and carbohydrate content of all the millets. Vitamin B content is important in millet bran strands.

Barnyard millet used

As it takes fewer than 30 minutes to achieve a soft, delicate texture, barnyard millet cooks really rapidly. To achieve a more earthy and nutty flavor, Barnyard Millets can be cooked. Use it to make Khichdi with a few steamed vegetables; it's also great fo r making Tiffin items like Idlis, Upma, and Dosas. It goes into making "Kheer," a delicious dessert.

Incorporate barnyard millet into your nutrition

After preparing food, all millets must be thoroughly moistened in order to extract their greatest nutritional value. To speed up the cooking process, you can soak and rinse this millet for about an hour. This millet takes about 20 minutes to cook. Use this in any grain dish or swap it out for rice. But be aware that these granules are smaller and rounder, so cook food very gently. You can also use the whole grain of barnyard millet to make porridges, bread, and crepes by grinding it into flour.

Nutritional values of Barnyard Millet

Barnyard millets are nutrient-dense particles. They are a good source of iron, protein, and fibre. During pregnancy, 100 g of barnyard millet offers 100% of the recommended daily intake of iron and 67% of the daily amount. Also, it includes a lot of calcium, which can assist your teeth and bones.

It includes the following nutrition per 100 g representing:

- Calories: 300 kcal
- Fat: 3.6 g
- Dietary Fibre: 13.6 g
- Protein: 11 g
- Carbohydrate: 55 g

- Calcium: 22 mg
- Vitamin B1: 0.33 mg
- Iron: 18.6 mg
- Vitamin B2: 0.10 mg
- Vitamin B3: 4.2 mg

Health benefits of Barnyard millet

A diet devoid of high-glycemic cereals helps barnyard millet manage diabetes. Making the right decisions helps manage weight, lower cholesterol, boost immunity, and enhance gut health. Make a balanced diet your first priority for both general health and successful diabetes treatment.

Here are some of the Barnyard Millet benefits:-

Maintains heart health

Barnyard millet's amylase retrogradation results in a rise in resistant starches, which may help patients with diabetes mellitus and cardiovascular disease, according to IIMR's conclusions on the nutritional advantages of millets. Furthermore, the high dietary fibre content of the food lowers bad cholesterol and increases good cholesterol, both of which are beneficial to heart health. Its magnesium concentration also lowers blood pressure.

Fights against anaemia

The high iron content of barnyard millet makes it an excellent choice for treating anemia. Eating small amounts of this grain provides essential elements needed for a normal metabolism. By include this millet in the diet, symptoms of anemia such as persistent weariness and low energy can be relieved, especially for those affected.

Manages digestive disorders

For those suffering from gastrointestinal diseases, barnyard millet is a godsend, since it can alleviate a variety of digestive issues. Due to the millet's high fiber content, problems like acidity, bloating, cramping in the stomach, and constipation are prevented. It also lowers the risk of diseases like diverticular disease, hemorrhoids, and colon cancer. Because it feeds the healthy bacteria in your stomach and boosts your immunity, barnyard millet is good for your gut health.

Skin and hair benefits

The health benefits of barnyard millet for skin and hair are noteworthy. Because of its abundance of phenols and flavonoids, it is a great source of antioxidants and is perfect for preserving the health of skin. Its iron and zinc concentration also helps to promote healthy hair development.

Manage type ll diabetes:-

NCBI research indicates that processed barnyard millet may help control type II diabetes. Because of its high polyphenol content and low glycemic index, it can help manage glucose surges linked to diabetes diseases by preventing the breakdown of complex sugars. Basically, this millet helps people with diabetes manage their condition.

Barnyard Millet Recipes for Better Health

Want to lose weight with the help of a nutritious diet? Be at ease when it comes to meal planning! Here are some cooking ideas to get you inspired. They only take a few minutes to prepare, and their warm, nourishingcharacter with a wealth of delicious nutrients is what makes them beautiful. To include barnyard millet into your cuisine, try these simple yet tasty recipes:

Barnyard Millet Upma Recipe

A hearty and satisfying breakfast or lunch option is barnyard millet upma. This grain, called kuthiraivali in Malayalam, has a low glycemic index and is devoid of gluten. Abundant in fiber, protein, iron, and calcium, it may help regulate blood pressure, cholesterol, and blood sugar in addition to fostering better digestion andimmunity.

A few basic ingredients and spices are needed to make the recipe for barnyard millet upma. To add color andnutrition, feel free to add whatever kind of vegetable you like.

Ingredients

- 1 cup barnyard millet
- 2 cups water
- 1 tbsp oil

- 1/4 tsp turmeric powder
- Salt to taste
- 1/4 cup chopped coriander leaves
- 1 tsp mustard seeds
- 1 tsp urad dal
- A pinch of asafoetida
- A few curry leaves
- 1 onion, finely chopped
- 2 green chillies, slit
- 1 tsp ginger-garlic paste

Instructions:-

- Rinse and let the barnyard millet soak in water for half an hour. Empty and set aside.
- In a pressure cooker, heat the oil. Curry leaves, asafoetida, mustard seeds, and urad dal should be added. Add the onion, green chilies, and ginger-garlic paste when they begin to sputter. The onion should be sautéed until golden.
- Add the salt and turmeric powder. Stir thoroughly.
- Add water to the soaked barnyard millet. After giving it a thorough stir, shut off the pressure cooker.
- Cook over high heat for 3 whistles, then reduce the heat and continue cooking for an additional 5minutes.
- Cut the flame and let the pressure to drop naturally.
- Using a fork to fluff the upma, open the cover. Decoratively add coriander leaves.
- Accompany hot dish with pickle, sambar, or coconut chutney.

Recipe Notes

- Add as many veggies as you wish to the upma by cutting them finely and putting them with theonion. Some of the vegetables you may use include carrots, peas, beans, capsicum, and others.
- Instead of using oil to prepare the dish, use ghee for a deeper flavor and fragrance.
- The amount of water needed for barnyard millet should be adjusted according to your desiredconsistency; it usually needs more water than other millets like rice.

Barnyard Millet Fried Rice Recipe

The wonder grain that is barnyard millet! It produces fantastically delicious fried rice. For a pleasant, nutritious supper, replace it with rice. I want to make some millet fried rice with a barnyard flavor! Try this simple dish that's quick to make at home.

Ingredients

- 1 cup barnyard millet, soaked for 30 minutes and drained
- 2 cups water
- Salt to taste
- 2 tablespoons oil
- 1/4 teaspoon garam masala
- 2 cups mixed vegetables, chopped (carrots, beans, peas, corn, etc.)
- 2 tablespoons coriander leaves, chopped
- Lemon juice to taste
- 1 teaspoon cumin seeds
- 1 onion, finely chopped
- 2 green chillies, slit
- 1/4 teaspoon turmeric powder
- 1/4 teaspoon red chilli powder

Instructions

Add the barnyard millet, water, and a dash of salt to a pressure cooker. Simmer until it releases threewhistles or becomes tender and fluffy. After that, use a fork to fluff it up and set it aside.

And voilà!

Let the oil sizzle over medium-high heat. Add those cumin seeds. Add the onion and green chiliesand stir until they become golden and vibrant.

Stir in the garam masala, red chilli powder, turmeric powder, and a little extra salt. Stir it thoroughlyfor around sixty seconds.

Include vegetables in the mixture! Stir-fry them for ten minutes, or until they are perfectly cookedand crunchy.

Stir in the cooked barnyard millet gently. Now just toss it well and you're ready for a flavor explosion! If necessary, adjust the seasoning.

Over the fried rice, scatter the coriander leaves and lemon juice. Heat and serve or pack for lunch.

Recipe Notes

For this recipe, you can use any kind of vegetable. For more protein, you can also include somepaneer, tofu, chicken, or eggs.Turn up the flavor by using ghee or coconut oil instead of your typical oil. It's like adorning yourmeal with a stylish cap!

Have a crazy feeling? For an added crunch and nutty flavor, add some roasted peanuts or cashews.Your rice is like an unexpected celebration!

Barnyard Millet Dosa Recipe

This easy-to-make, delicious millet dosa from Barnyard is a crunchy, nourishing morning option. This grain is free of gluten and suitable for those with diabetes. It is packed with of fiber, protein, iron, and calcium. It may help with blood pressure, cholesterol, blood sugar regulation, digestion, and immunity building. Your diet would benefit greatly from include this millet dosa as a great way to accept and enjoy this nutritiousgrain.

Ingredients

- 1 cup barnyard millet
- 1/4 cup urad dal
- 1/4 cup poha
- 1 teaspoon methi seeds
- Salt to taste
- Oil or ghee for frying
- Water as needed

Instructions

- In separate bowls, wash and soak the methi seeds, urad dal, poha, and barnyard millet for four hours.
- After draining the water, finely crush the millet in a grinder or mixer. Move to a large bowl.
- Using the same mixer or grinder, grind the methi, poha, and urad dal seeds into a smooth paste. As necessary, add water to get a smooth consistency. Transfer to the same bowl as the millet batter.
- After completely blending the two batters, taste and adjust the salt seasoning. Place a lid on the bowl and let it ferment in a warm place for eight hours or overnight.
- A dosa tawa or griddle should be warmed up and lightly oiled or glazed with ghee. Pour out thebatter and create the ideal circle with it, like a master artist would. Once the sides are lightly coated with oil or ghee, fry it over medium-high heat until it turns golden and crispy! After flipping it over, quickly fry the opposite side. Continue with the leftover batter.
- Warm up the barnyard millet dosa and serve it with chutney, sambar, or podi.

Recipe Notes

- To kick things up a notch in taste, toss in some chopped green chillies, ginger, curry leaves, or cuminseeds into the batter.
- Got extra batter? No worries! Place it in an airtight container and store it in the refrigerator for up tothree days. Just before dosa time, a splash of water might be needed to get that perfect consistency.

- You can also make idlis with the same batter by steaming them in idli moulds for10 to 15 minutes

Conclusion

We have examined the nutritional benefits of millets and found out about their nutrient content. Millets are superior on a number of fronts, especially when compared to crops that are commonly consumed like rice. In addition to their immense medicinal value, the fact that they are grown without the use of harmful pesticides and other chemicals makes them an excellent addition to many Indian meals. Millets aim to address the various wellness aspects of the body to ensure that you can manage your weight with a healthy, balanced diet. High blood cholesterol and diabetics can both benefit from millets. Therefore, millets should be a regular part of a person's diet in order to help them lose weight and improve their overall health.

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FIELD DODDER (CUSCUTA) IN FORAGE CROPS – HOW TO CONTROL IT?

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Introduction

Lucerne (alfalfa) (*Medicago sativa* L.) and Egyptian clover (berseem) (*Trifolium alexandrinum* L.) are the major forage crops grown worldwide. In India, these crops are extensively grown in irrigated areas during winter season. Field dodder (*Cuscuta campestris* Yuncker) is a serious problem in these forage legumes and lucerne was reported to be highly susceptible to Cuscuta than the Egyptian clover (Farah and Al-Abdulsalam 2004). Plants infested with field dodder gradually weaken, their lush growth dwindles and they have very small vegetative and generative yield. Damage caused this way may eventually cause total destruction of the host plant. We are therefore focusing in this paper on various control options for field dodder, from preventive ones (e.g. mechanical measures or choice of tolerant cultivars) to biological and chemical methods of control.

Botanical description

- *Cuscuta campestris* is an annual stem parasitic plant. It lacks normal roots and leaves, but does bear flowers and fruits.
- *C. campestris* stems are thread-like, yellow or pinkish-yellow in colour, are much branched and grow to 0.8 mm.
- *C. campestris* flowers are white or greenish, aggregated in groups of 3-8 in spreading inflorescences, cymose (flat-topped or convex flower cluster in which the uppermost flowers open first. Flowers have 4-5 sepals which are united at base.

The fruit is a light-brown, 2-4-seeded boll. Seeds are oval, light-brown or brownish, to 1.25-2.5 mm long, 1-1.5 mm wide.

Parasitism

Cuscuta seeds usually germinate on or near the soil surface. Its seedlings are rootless and have leafless stem. After emergence, the seedlings twin around the leaf or stem of host plant (Fig. 1). Haustoria from the Cuscuta penetrate the host and establish a parasitic union. Once the Cuscuta is attached to a host plant, it remains parasitic until harvest. It reproduces mainly by seeds and to a lesser extent by shoot fragments.

Fig.1: Cuscuta vine twin around lucerne plant.

Fig. 2: Infestation of cuscuta in lucerne

Fig. 3: Infestation of cuscuta in clover

Damage caused by Dodder in Lucerne and Egyptian clover

- During the seed production of these economic crops, dodder seeds are harvested with the crop seed and being similar in size and density to the crop seeds, it is extremely difficult to separate from the crop seed.
- Plants infested with field dodder gradually weaken, their lush growth dwindles and they have very small vegetative and generative yield (Fathoulla and Duhoky, 2008).
- The damage consists mainly of reduced fresh biomass yield and significantly reduction in crop seed production. It may reduce seed yield by 60 per cent. For certified seed production of Lucerne, its population should be its population should be < 0.05 per cent.
- Some Cuscuta species carry viruses such as the cucumber mosaic virus or tobacco rattle virus, thus causing additional difficulties for crop growing and indirectly reducing yields

- It is also a contaminant of hay and threatens the small seeds industry through seed contamination.

Damage caused by dodder on animals

- Livestock fed on hay (fresh biomass of legumes, primarily alfalfa and clover) containing 50- 60% field dodder loses weight.
- More frequent miscarriages may occur.
- Indigestion problem will occur.
- Dodder consumption in bulk feed causes diarrhea, vomiting, palpitation and heavy breathing in rabbits and horses.

Management

It is extremely difficult to achieve complete control of Cuscuta because its seeds have a hard seed coat, can remain viable in soil for many years, and continue to germinate and emerge throughout the year. However, by following methods we can reduce the infestation of Cuscuta.

Prevention

- Use of clean crop seed is vital. Seed should be obtained from a known source.
- Cleaning all nearby field, field bunds, irrigation channels and waste lands at frequent intervals;
- Use of well decomposed and rotted manure;
- Machinery used for reaping and other intercultural operations in infested areas should be cleaned before moving to other areas.
- Deep ploughing can help reduce the seed burden by burying dodder seed. Most dodder seed will not germinate from a depth of more than 7.5 cm.

Mechanical methods

- Separation of Cuscuta seeds from lucerne by equipment comprising velvet covered rollers to which the rough seeds of Cuscuta stick while the smoother crop seeds pass over.
- Manual removal and frequent inter-row cultivation or shallow tillage before the parasite attaches the host plant
- Cuscuta can be pulled out and buried.

- The seed of lucerne are to be treated with 5 to 10 per cent solution of common salt for five minutes. The light seeds of Cuscuta will float on the surface of water.
- More extensive infestations in lucerne are also sometimes treated with overall flaming, as the crop is able to recover.
- Grazing by sheep can result in significant suppression of dodder by their grazing habits.

Cultural control :

- Crop rotation with non-susceptible crops can be helpful. Cereals such as wheat, barley, oats, triticale and cereal rye are virtually immune from attack, and some broad-leaved crops may also be sufficiently resistant, including soybean, kidney bean, squash, cucumber and cotton.
- Postponement of sowing or replanting is also considered an important cultural measure.
- The varieties of lucerne viz., 'LLC 6' and 'LLC 7' are moderately tolerant to Cuscuta infestation.
- Dense crop canopy is a valuable component because deep shade suppresses the coiling and attachment of Cuscuta.

Herbicidal control:

The following herbicides are recommended for effective control of dodder in lucerne.

- Pendimethalin@ 1 kg a.i./ha (pre-emergence) continues to be the one of the most commonly used herbicides.
- Herbicides for control of established parasites include diquat (@ 6-10 kg/ha 5-10 days after sowing) used for non-selective spot spraying of isolated patches.
- Glyphosate or Paraquat (0.05-1%) spray with a high volume sprayer will kill dodder. Though selectivity is narrow and repeat treatments may be needed.
- Pre-sowing application of diuron @ 2.0 kg/ha or fluchloralin @ 1 kg/ha or EPTC @ 3.0 kg/ha or MCPB @ 0.75 kg/ha after 30 DAS or pronamide @ 1.0 kg/ha just after sowing controls the weeds in lucerne crop.

Biological control

- Use of bio-herbicide (mycoherbicide) like Lubao II Colletotrichum gleosporioides f. sp. Cuscutae for Cuscuta sp.

- The involvement of the agromyzid fly Melanagromyza cuscutae and the gall-forming weevils Smicronyx spp. controlled dodder effectively.

Conclusion

Successful control of field dodder requires the integrated protection program that begins with monitoring of dodder in field, adequate crop rotation, planned growing of crops that are not suitable hosts to field dodder, a variety of preventive measures and physical removal, the use of tolerant cultivars and biological agents, as well as treatments with herbicides when the problem cannot be solved any other way.

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SUSTAINABLE PRACTICES IN NATIVE CHICKEN REARING

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Introduction

Native chicken in India plays a significant role in contemplating rural economy. Native birds play a major role in providing subsidiary income and nutritional security to the people of India. A total of 19 native chicken breeds have been reported and registered in India by ICAR-National Bureau of Animal Genetic Resources, Karnal, India, which is the nodal agency of Government of India for registering breeds of livestock and poultry. At present, the Indian native chicken population is 37.2% of the total poultry population, which contribute around 17.8% of the total egg production in the country. In India some of the important breeds/varieties which have been documented are Aseel, Kadaknath, Ghagus, Nicobari, Ankaleshwar, Bursa, Chitagong, Denki, Daothigir, Haringhatta Black, Kalashthi, Kashmir Faverolla, Miri, Punjab Brown, Tellichery, Mewari, Kaunayen, Hansli, and Uttara. In the recent years, native chickens are gaining more importance due to the raising demand for their meat and eggs as the consumers are willing to pay higher price due to their perceived health benefits. Due to the high demand for native breeds products many farmers are rearing them on a large scale by providing special facilities. Appropriate measures to rear native chicken are:

1. Brooding of the native chicks

The most commonly used brooding method is floor brooding method. This requires less equipment and accommodates large number of chicks. The brooding ring should be arranged which may be made of a cardboard sheet or a thin strip of metal. The height of the brooding ring should be 30 to 45 cm. Place the newspapers on the floor in the brooding ring and cover it with some type of bedding material or litter. Mostly saw dust is used as litter material. Proper temperature should be maintained for the chicks as they are cold blooded during their first few weeks and cannot maintain their body temperature. The warmth should be provided using the heat lamps or bulbs. During the first week the brooding temperature should be about 95 ^{0} F and reduced by 5^{0} F each week from the initial temperature provided to the chicks upto six weeks. The feeders and waterers should be arranged in circular manner. In one meter brooder about 250 to 300 chicks can be accommodated.

2. Feed and water management

Balanced nutrition should be provided to the chicken as they are reared for commercial purpose. Farmers provide the grains they have cultivated to the chicken as feed. The birds reared on extensive system were let free in the yard. During scavenging, the birds generally feed on kitchen waste, earthworms, grasshoppers, ants, green grasses, leafy vegetables, seeds etc. In addition to scavenging, farmers also offer broken rice, bajra, sorghum, maize etc. to their birds. In commercial reared birds, the chicks should be provided with complete nutritive diet.

Hygienic water is one of the most important key factors for good health and growth of poultry. Adequate water should be provided to the chicks. The waterers should be cleaned thoroughly on daily basis. Multiple sources of water should be avoided to prevent *E.Coli* infections. The water should be mixed with sanitizers as per recommendations. Never mix live vaccines in sanitized water.

3. Vaccination and deworming

Native chicken breeds are perceived to have better resistance to bacterial, viral and protozoan diseases. If commercially reared, vaccination should be given in advance to prevent spread of diseases and preventive measures should be followed. Day old chick should be vaccinated with Marek's disease vaccine subcutaneously. New castle disease vaccine should be given on 7th, 28th days and on 9th and 18th weeks. On 15th day Gumboro disease vaccine should be administered to the chicks and fowl pox vaccine in 8th week. Chicks should be regularly dewormed to prevent parasitic infections.

4. Disease management

Most of the farmers rear native chicken in extensive rearing system which exposes them to various disease causing organisms. To reduce the risk of diseases in the flock proper biosecurity measures should be followed.

5. Isolation and treatment of sick birds

The farmer should able to differentiate between the healthy and sick birds. Common signs observed in sick birds are reduced feed and water intake, bird looks tired and inactive with loose and ruffled feathers. It may also have diarrhea or respiratory problems. Sick birds should be isolated from the remaining birds immediately to prevent the spread of the disease to healthy birds. Isolated birds should be kept in a separate room. Self-medication should not be done by the owners. Veterinarian suggestions should be followed in treating the sick birds.

Ethno-veterinary practices are followed in rural areas as they are cost-effective and easily accessible. They employ several practices, such as hot water to kill the lice present in the sheds. Turmeric is used for external application on wounds. Moringa leaves either sun dried or soaked in water helps in treatment of diarrhea and Newcastle disease. Aloe vera is used for prevention as well as treatment of diarrhea and Newcastle disease. Turmeric, garlic and onion are used to cure respiratory diseases. Neem oil is used to control flies in the shed.

6. Egg production

Over the past decades, the eggs and meat produced by the native chicken has increased which lead to commercialization of the native chicken. Birds starts laying eggs after 25 to 28 weeks. They produce about 60-80 eggs in a year in three to four clutches with average egg weight of 35-45 g. Birds prefer darker areas in the shed for laying eggs. Nest boxes should be provided in the shed for chicken. Plastic cans, rubber baskets, earthen pots, wooden crates are commonly used as nesting boxes. Rubber tires are commonly used as nest boxes by arranging one over the other. This prevents the cracking of eggs. Crushed egg shells or calcium supplements should be provided to prevent the production of thin shelled eggs.

7. Construction of a poultry shed

The direction of the shed should be in east-west as it provides good light and heat to the chicks. The foundation of the shed should be of concrete with 1 to 1.5 feet below the surface and 1 to 1.5 feet above the ground level. The extension of the floor should be 1.5 feet on all sides that helps in preventing the entry of rodents and snakes. The side walls of the shed should be 1 feet high and iron wire or mesh should be installed upto 7 feet. The roof of the shed should be covered with asbestos sheets. The door should be opened outwards and the footbaths should be arranged at the doors to prevent the entry and spread of infections. The floor of the shed should be covered with litter material for about 2-3 inches depth. Commonly used litter material is paddy straw or wood shavings.

8. Summer management of native chicks

Increase in temperature lead to heat stress. Heat stress is a condition of imbalance between heat generation and heat loss from the body. . Heat stress has a direct effect on feed intake, growth, and body weight of the birds. It affects the health, egg production and egg quality of the chicken.

- Overcrowding should be avoided.
- Shifting, transportation and vaccination of the chicks should be done in the cooler parts of the day.

Housing management

To reduce the heat stress, the roof of the shed should be white washed or covered with paddy straw. Planting trees around the shed helps in reducing the heat by providing shade. Installing fans or foggers also helped in reducing the temperature inside the shed.

Water

In summer, water consumption increases 3 to 4 times more than normal. So, it is important to provide cool and clean water abundantly. Covering the water tanks with gunny bags or keeping the tank indoors helps in prevents the direct exposure to the sunlight. Use of ice cubes in tanks also helps in providing cool water to birds.

Feed

In summer, consumption of the feed is reduced due to increase in temperatures which may lead to decrease in body weight, egg production and shell quality. Feed should be offered only during the cooler parts of the day and 70-80 per cent of the feed should be offered in early morning and remaining part in the late evening. The frequency of feeding should be increased.

9. Winter management

Decrease in the temperature leads to cold stress. Birds should be protected from the cold winds by covering the open areas of the shed with gunny bags. The gunny bags should be hanged overnight until the sun rises. There should also be arrangement of exhaust fans to remove impure air. Litter gives warmth to the birds and it should be around 6 inches depth.

During winter birds consume less feed and water. So, a constant supply of food should be given to the birds. The water should not be cold, if cold hot water should be mixed to bring the temperature to normal room temperature.

10. Vices (bad habits)

Vice is a faulty bad habit acquired by the chicken which effects the health, behavior and wellbeing. Once a vice develops, it spreads quickly in the flock which leads to losses to the poultry owner. Most common vices seen in chicken are cannibalism, egg eating and pica.

a. Cannibalism

It is the common vice observed as it occurs mostly due to overcrowding or nutrient deficient diet. The birds start to attack their pen mate and peck and eat its flesh (comb, vent etc.) which leads to deep wounds, loss of production and sometimes mortality.

Prevention

- Debeaking should be done to prevent cannibalism to develop.
- Feed should be available continuously.
- Overcrowding should be avoided
- Birds involved in cannibalism should be isolated from the flock.

b. Egg eating

Sometimes birds start to eat their own eggs. It may start due to the accidental breakage of eggs or cracked eggs, not removing the eggs from the nesting pens for a long period of time. It is difficult to control this vice.

Prevention

- Debeaking, keeping the birds that has developed this vice in cages where egg rolls away, beyond the reach of the bird after laying of eggs helps in controlling this vice.

c. Pica

Birds start to eat materials that are not fit for consumption such as threads, litter material etc.

Prevention

- Good managemental care and balanced nutrition are recommended to prevent this vice from developing.

Conclusion

Rearing native chicken is a sustainable and profitable as they have several advantages such as high disease resistance, has high nutritional value and flavor, can adapt to local conditions. Native chicken rearing requires low maintenance but it creates more income for small-scale farmers. By implementing proper management practices, we can utilize their full potential to help farmers and consumers.

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FROM SEED TO SUPERFOOD: THE ART OF GROWING CHIA CROP (*SALVIA HISPANICA*)

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Abstract

Chia seeds, derived from the plant *Salvia hispanica*, have garnered widespread acclaim as a nutrient-dense superfood with diverse culinary and health applications. This abstract provides an overview of the nutritional composition, health benefits, and culinary uses of chia seeds in 200 words. Chia seeds are rich in essential nutrients, including omega-3 fatty acids, protein, fibre, antioxidants, vitamins, and minerals. Their high omega-3 content, predominantly in the form of alpha-linolenic acid (ALA), makes them a valuable source of heart-healthy fats, supporting cardiovascular health and reducing inflammation. Additionally, chia seeds boast an impressive fibre content, promoting digestive health, regulating blood sugar levels, and aiding weight management by inducing satiety. These tiny seeds also contain significant amounts of calcium, magnesium, phosphorus, and manganese, essential for bone health, muscle function, and energy metabolism. Moreover, their antioxidant properties help combat oxidative stress and protect cells from damage caused by free radicals, potentially lowering the risk of chronic diseases like cancer. In culinary applications, chia seeds are versatile ingredients, often used in smoothies, puddings, baked goods, salads, and yogurt toppings. Their ability to absorb liquid and form a gel-like consistency makes them an excellent vegan egg substitute in recipes. With their neutral flavour profile, chia seeds seamlessly integrate into various dishes, enhancing both taste and nutritional value. In conclusion, chia seeds stand out as a nutritional powerhouse, offering an array of health benefits and culinary possibilities that make them a valuable addition to a balanced diet.

Introduction

Chia (*Salvia hispanica L.*) is a mint plant in the lamiaceae family, native to southern Mexico and Northern Guatemala (Ayerza and Coates, 2009) and now it is also cultivated in Southern parts of India. It is a staple food of the central America civilizations in preColumbian period, along with corn, beans and amaranthus (Fernandez *et al.,* 2006). It is considered as pseudo cereal and oil seed crop cultivated for edible purpose It is an annual herbaceous plant considered as a novel food, the area under cultivation of chia crop is expected to rise in the coming days as it requires less water and is a drought resistant crop comes up very well under dry land condition. Chia is a plant characterised by low water consumption and well adopted to arid and semi-arid regions. The cultivation of chia is gaining popularity in Africa because it is considered as a good nutritional and healthy food. The plant has high percentage of fibre, protein, omega-3, omega-6 and essential fatty acids. It is grown for human consumption especially due to its richness in omega-3 fatty acids, fibre and is a great source of anti-oxidants and amino acids particularly lysine. The seeds contain about 20% protein, 35 % oil and an impressive 25% dietary fibre and also offer a range of vitamins and minerals including calcium, phosphorus magnesium and Zinc. In recent years, some farmers sowing interest to grow chia crop due to its nutrient content and climate resilience. Hence there is need to standardise agronomic practices for further popularisation of this crop which can play a major role in feature diversification of agriculture system in India.

Locality:

Chia is a plant characterized by low water requirement and well adapted to arid and semiarid regions it is cultivated in the worldwide with an area of 126 thousand hectares with a production of 103 thousand tonnes. Bolivia in South America is the largest producer of Chia with 38 per cent of world production (Fort, 2015) followed by Peru with 32 per cent and United States of America with 6.3 per cent.

Package of practices:

Biology:

Chia (*Salvia hispanica L.*), is an of the Lamiaceae (mint) family and native to mountain areas of Mexico and Guatemala (Ixtaina et al., 2008). It has been consumed and domesticated as a staple food crop by Mesoamerican Indian tribes since 2600 B.C. The crop can grow up to 1.5 meter height and the main edible part is seed (Karim et al., 2016). Chia produces white or purple flowers and has opposite arranged leaves. Chia is an annual herbaceous plant that can reach nearly 1 meter (3 feet) in height. Its lime-green leaves are oppositely arranged and have serrated (toothed) margins. The plant bears spikes of small blue, purple, or white flowers that have a high rate of self-pollination. The small oval seeds are about 1 mm (0.04 inch) in diameter and feature a shiny, mottled, or speckled seed coat that ranges in colour from dark brown to gray-white.

Duration:

The duration of crop cycle is most cases from 140 to 180 days, but since Chia is extremely sensitive to photoperiodic day length (a macro-thermal short-day species), the growing cycle absolutely depends on the latitude where it is planted.

Climate:

Chia (*Salvia hispanica L.*) is a short-day plant with oil-rich annual herbaceous plant strong sensitivity to photoperiod and temperature (Baginsky et al. 2016). Chia, with wider adaptability to varied agro-climatic conditions, is considered as an alternative crop not only for maintaining food security but also to mitigate climate change effect (Herman et al. 2016).

Winter is the ideal time to plant and grow chia seeds and the very early spring, because it is considered as the short-day plant and cannot grow in long day season. But they cannot tolerate frost and snow.

1.	Rainfall	1200-2000 mm
2.	Temperature	10-45^{0}c
3.	Sowing temperature	25-40^{0}c
4.	Harvest temperature	25-40^{0}c

Soil: Chia plants can grow very well in sandy loam, well-drained soils with a low nutrient content, moderate salinity, and soil having pH of 6-8.5 (Yeboah et al., 2014).

Land preparation: Traditional cultivation techniques of *S. hispanica* include soil preparation by disruption and loosening followed by sowing

Seed rate: In modern commercial production, a typical sowing rate of 2.5- 3 kilograms per acre and spacing of 60cm x 45cm are usually applied.

Propagation: Chia seeds are propagated from both seeds and seedlings, growing chia plant from seeds can be best job, prepare the soil for crop, just sprinkle seeds over the soil and stab them gently and cover them with soil. Watering should be done at regular intervals, chia seeds start sprouting within 7 to 10 days. After the seedlings grow up to 7-10 cm tall with 5-6 pairs of true leaves, thin them as they grow.

Types of seed: There are two types of Chia seed, one is black chia seed and another is white chia seed.

Time of sowing: Winter is the ideal time to plant and grow chia seeds and the very early spring, because it is considered as the short-day plant and cannot grow in long day season. But they cannot tolerate frost and snow.

Fertilizer management: Chia plants can be fertilized with NPK 90:60:75 kg NPK ha^{-1} (two portions) and biofertilizer for the best growth and yield. Maintaining adequate phosphorus levels is especially important at the early stages of plant development.

Irrigation: Chia crop should be irrigated frequently for better yields, in chia plantation. The plan may need, from one to five irrigations per growing season, depending on climatic conditions and rainfall.

Weed management: Herbicides like bentazon and fluazifop-p-butyl applied post-emergence do not significantly affect the plant height and biomass yield in chia (*Salvia hispanica L*). Other herbicides like linuron, pendimethalin, and oyxfluorfen do not seem to be a viable option for weed control in chia crop

Harvesting: Plant starts yielding by 100-140 days after plantation. Harvesting is done during winter month as the plant become dormant.

Yields: Average yield per acre is 350- 400 kg chia seeds.

Benefits

In recent years, chia seeds have become very popular for its nutritional merits which consisted of 20–34% fat, 60% α-linolenic and 20% linoleic acids. Other valuable constituents of chia seed include 16–26% protein (mainly prolamins), 23–41% dietary fibre, ample quantities of vitamins (mostly B complex), minerals (mainly Ca, Mg, P and K), extraordinary mucilaginous fibre and antioxidant. Chia seeds show anti-inflammatory and anti-diabetic properties, and also works well against cardiovascular diseases and hypertension. Chia seeds can be a food supplement due to its high contents of polyunsaturated fatty acids, anti-oxidants, vitamins, minerals, and protein in seeds. Chia seeds are an oilseed that contain fats, carbohydrates, dietary fibre, proteins, vitamins (A, B, K, E, D), minerals and antioxidants. They are also free of mycotoxins and gluten. Chia seeds have many nutritional benefits, including supporting the digestive system, promoting healthy skin, stronger bones and muscles, and reducing the risk of heart disease, diabetes, and other non-infectious diseases (Mohd Ali et al. 2012).

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DRAGON FRUIT DIARIES: THE ESSENTIAL GUIDE TO DRAGON FRUIT MANAGEMENT

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Introduction

Dragon fruit (*Hylocereus* spp.) is a fast-growing, xerophytic, vine-like cactus plant, belonging to genus *Hylocereus*. It is also known as Pitaya, pitahaya, thangloy, strawberry pear, noblewoman and queen of the night throughout the world. In India, it is also known as 'Kamalam'. The origin of Dragon fruit is the tropical and sub-tropical forest regions of Mexico and Central and South America (Mizrahi *et al.*, 1997) and it is being cultivated in Southeast Asian countries including Malaysia, Indonesia, Taiwan, Thailand, Sri Lanka, Bangladesh and Vietnam. Recently, India also started cultivation of dragon fruits. The fruits are oblong–oval with bright red skin covered with green bracts or "scales," accounting for the name dragon fruit (Morton, 1987; Paull, 2004). The flesh is sweet, delicate, white or red–purple, and contains numerous tiny black seeds. The fruit is non climacteric and has the best flavor when harvested at full red color (Nerd *et al*., 1999).

Being a cactus family and requires long day for flowering, dragon fruit cultivation is well suited in the agro-climatic regions of Southern, Western and North Eastern India that are dry and frostfree.

CULTIVATED *HYLOCEREUS* SPP. AND THEIR DISTINGUISHED FRUIT CHARACTERISTICS (Wakchaure *et al.*, 2020)

1. *Hylocereus undatus* : Red peel with white pulp

2. *H. monocanthus* or *H. polyrhizus* : Red peel with violet-red pulp
3. *H. costaricensis* : Dark red peel with deep red pulp
4. *H. magalanthus* : Yellow peel with white pulp

In India widely grown cultivars of dragon fruit are the red skin-white flesh (93%) followed by red skin-purple/red flesh (6.5%) and yellow skin-white flesh (<0.5%).

BIOLOGY OF DRAGON FRUIT (Hossain, 2021)

The plant is a climbing cactus vine that grows well in dry areas. Stem is triangular (3 sided), green, fleshy, jointed with many-branched stems. Each stem segment has 3 flat, wavy wings and may have 1-3 small spines, or are spineless. Its flowers bloom only at night, hence the plant is sometimes also called 'Moonflower'or 'Lady of the Night'. The flowers are white and large, bell - shaped and produce a sweet fragrance when in bloom. The fruit is oval, elliptical or pear - shaped and non-climacteric.

NUTRITIONAL VALUES OF DRAGON FRUIT

Dragon fruit contains significant amounts of minerals such as potassium, phosphorus, sodium and magnesium; higher than those of mangosteen, mango and pineapple (Gunasena*et al.*, 2007; Stintzing*et al*., 2003; To *et al*., 1999) and all sources of vitamins (Choo and Yong, 2011). Mature Dragon fruits have higher TSS, which is mainly higher in autumn fruits than in summer fruits (Nomura and Yonemoto, 2005). It is well-known for its rich vitamin C, phosphorus, calcium as well as antioxidant contents (Morton, 1987). The fresh fruit contains 82.5-83.0 per cent moisture, 0.16-0.23 per cent protein, 0.21-0.61 per cent fat, 0.7-0.9 per cent fiber. 100 g of fresh fruit pulp contains 6.3-8.8 mg calcium, 30.2-36.1 mg phosphorous, 0.5-0.61 mg iron and 8-9 mg vitamin C (TFIDRA, 2005). The red flesh is additionally rich in Betalains, meeting the increasing trade interest in antioxidant products. Dragon fruit is rich in nutrients like vitamin B_1, B_2 , B_3 , C, high fiber content, minerals like Ca, Fe, P, with low amount of carbohydrates and no fats. All the mentioned research findings have been stated that Dragon fruit contains several vitamins and minerals that are important for a healthy body.

DISEASES OF DRAGON FRUIT

Fungal Diseases (Chandini and Sushma, 2021)	
Stem Canker	*Neoscytali diumdimidiatum*
Anthracnose	*Colletotrichum* spp.

Fruit Blotch/ Rot	*Bipolaris cactivora*
Stem Rot	*Fusarium proliferatum*
Stem Spot/ Brown Spot	*Botryospaeria dothidea*
Alternaria Blight	*Alternaria* spp.
Bacterial Diseases (Balendres and Bengoa, 2019)	
Soft Rot	*Enterobacter cloacae*
Viral Diseases (Balendres and Bengoa, 2019)	
Necrotic Spot	*Cactus Virus* X
Nematode Disease (Balendres and Bengoa, 2019)	
Root Knot Nematode	*Meloidogyne* spp.

CURRENT DISEASE MANAGEMENT STRATEGIES

a. Cultural and physical approaches

Temperature management, hot water treatment, and gamma irradiation have been reported to reduce disease incidence and severity of dragon fruit diseases. Storing fruit at 6°C for 21–26 days can reduce storage rots caused by fungal pathogens *e.g.*, *Alternaria alternata, B. cactivora, N. dimidiatum and C. gloeosporioides* (Ngoc *et al.*, 2018).

Hot water treatment for 2 min at 50°C, before storage in 12°C for 21 days, reduced lesion diameter by 63.1% without significant effect on the fruit's sensory qualities (Vilaplana *et al.*, 2017). Irradiating fruits at 800 Gy or less was also effective in inhibiting or reducing fruit decay, although minor changes in fruit quality were observed (Wall and Khan, 2008).

b. Biological control

Spent mushroom sawdust applied in disease-conducive soil reduced the incidence of basal stem rot to 3–12 per cent, compared to that of the control which is 44–59% (Choi *et al.*, 2007). Bae *et al.* (2013) evaluated 943 microbial isolates against *B. cactivora* and identified two bacteria (*Bacillus subtilis* and *B. amyloliquefaciens*) with strong antimicrobial activity. The *Bacillus* sp. inhibited mycelial growth and spore germination of *B. cactivora*. The effect was comparable to the chemical control treatment difenoconazole. Mixtures of azoxystrobin (200 g/L) and difenoconazole (124 g/L) has been recommended in controlling diseases of dragon fruit, particularly anthracnose and stem canker.

There were two Bacillus sp. from the surface of dragon fruit twigs that were able to inhibit growth and conidial germination of anthracnose pathogens. These biocontrol agents were *B. methylotrophicus* strains PB182, PB255 and PB257, and *B. subtilis* PB223. Accordingly, *B. methylotrophicus* produces volatile compounds that inhibit mycelial growth, which also results in reduced virulence of the pathogen in dragon fruits (Noegrohati *et al.*, 2019). Anthracnose lesion in dragon fruit twigs was reduced by *B. methylotrophicus* in both protective and curative tests. Aside from bacteria, a fungus has been also identified that has antimicrobial activity against *C. gloeosporioides*. Crude extracts of *Penicillium oxalicum* inhibited the growth of *C. gloeosporioides* in disc diffusion test by 33 per cent and the diffused non-volatile metabolite of this fungus inhibited the pathogen's growth by 97 per cent at 7 days post-incubation (Meetum *et al.*, 2017). *Penicillium oxalicum* is one of the potential biocontrol agents, which can suppress the growth of *C. gloeosporioides* (Mamat *et al.*, 2018).

The use of silicon to reduce the incidence and severity of various fungal diseases in dragon fruit plants has been also reported. Plants treated with silicon (5.0 ml/L) had lower disease incidence and severity compared to the control treatments and lower silicon treatments (1.5 and 2.5 mL/L) (Faziha *et al.*, 2019).

Conclusion

Dragon fruit (Hylocereus spp.) is a type of cactus plant that grows quickly and has xerophytic growth characteristics, similar to vines. Cactilian dragon fruit cultivars prefer to grow in dry and frost-free agro-climatic regions of Southern, Western and North Eastern India, where long days are necessary for flowering. Dragon fruit is commonly grown in India with red skin and white flesh (93%), as well as red-purple/red flesh (6.5%) and yellow skin to white meat (0.5%). It is rich in minerals such as potassium, phosphorus and magnesium that are higher than those found in mangosteen, mango or pineapple. The nutritional value of dragon fruit is high in vitamins B_1, B_2, B_3, C and fiber along with minerals such as Ca, Fe, P, low carbohydrate content, but zero fats. According to the research findings, Dragon fruit provides various vitamins and minerals that are crucial for maintaining good health. The incidence and severity of disease rates and diseases in the dragon fruit can be reduced by temperature management, hot water treatment, and gamma irradiation. To prevent the formation of storage rots caused by fungal pathogens, it is recommended to store fruit at 6°C for 21–26 days. Applied mushroom sawdust in disease-conducive soil reduced the incidence of basal stem rot from 44 to 59 per cent to 3-12 per cent.

Mycelial growth is inhibited by volatile compounds produced by *B. methylotrophicus*, which also reduces the pathogen's virulence in dragon fruits. Anthracnose lesion in dragon fruit twigs was reduced by *B. methylotroph* Along with bacteria, there is a fungus that has antimicrobial capabilities against *C. gloeosporioides.* It has been reported that silicon has also been used to reduce the incidence and severity of fungal diseases in dragon fruit plants. Treatments with lower levels of silicon (5.0 ml/L) resulted in reduced plant disease rates and severity.

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NURTURING TOMORROW'S SWEET HARVEST– A SUCCESS STORY OF A YOUNG ENTREPRENEUR

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Introduction

Sugarcane, (*Saccharum officinarum*), perennial grass of the family Poaceae, primarily cultivated for its juice from which sugar is processed. Most of the world's sugarcane is grown in subtropical and tropical areas. The by-products from cane sugar processing, namely the straw and bagasse (cane fibres), can be used to produce cellulosic ethanol, a second-generation biofuel. Other sugarcane products include molasses and the plant itself can be used as thatch and as livestock fodder. Good quality sugarcane seedlings are the need of the hour in order to get high yield and disease free plants. Here is a one young farmer practicing Sugarcane nursery to cater the needs of the farmers.

Shashikumar Kashmmanavar was born and brought up in an agriculture family and completed a Diploma in Mechanical Stream. Due to a lack of opportunities and as an agriculture background personnel, passionate about sustainable agriculture, embarked on the journey in 2020 by establishing a sugarcane nursery with a vision to cultivate high-quality, disease-free crops. His journey began with a clear future forecast to contribute to the agricultural sector by producing premium-quality sugarcane seedlings for sustainable farming practices. The nursery serves as the foundation for realizing this vision, acting as a hub for propagating healthy seedlings and fostering their growth.

Saplings planted on portraits. Careful site selection and meticulous preparation were paramount in ensuring the success of the sugarcane nursery. Identified a well-drained area with fertile soil, adequate sunlight, and access to water sources. The site was cleared, leveled, and enriched with organic matter to create optimal growing conditions. Healthy Sugarcane Saplings by Local Women Laboure's Selecting high-quality seeds from disease-resistant varieties was crucial for establishing a robust nursery. sourced certified sugarcane seeds from reputable suppliers and also from progressive local farmers and employed.

Techniques such as single bud cutting and pre-soaking to propagate healthy seedlings with strong root systems. Implementing effective nursery management practices was essential for nurturing vigorous sugarcane seedlings. He maintained optimal soil moisture levels, controlled weed growth, and monitored pest and disease outbreaks through regular scouting and timely interventions to ensure the health and vitality of the nursery. Now it's a Center of Study for beginners.

The Shri Jyotiba SugarCane Nursery caters to 4-5 Lakhs of sugarcane seedlings per annum. He charges a reasonable Rs.2.20 per seedling. For the Past 4 Years, he generated Rs. 40-50 Lakhs of Revenue from the support of all surrounding farmers. In line with his commitment to sustainability, adopted eco-friendly cultivation techniques in the sugarcane nursery. Utilizing organic fertilizers and implementing water conservation measures minimized environmental impact while promoting soil health and biodiversity. He regularly assessed growth parameters, conducted soil tests, and solicited feedback from agricultural experts to refine his practices and enhance nursery productivity.

He actively engaged with fellow farmers, agricultural extension services, and local communities to share knowledge and exchange best practices related to sugarcane cultivation. Collaborative initiatives such as field demonstrations and workshops facilitated mutual learning and empowerment within the farming community.

Looking ahead, he committed to furthering the success and sustainability of his sugarcane nursery. By embracing innovation, adopting emerging technologies, and fostering partnerships, the aim is to expand production, enhance product quality, and promote environmental stewardship in sugarcane farming.

Conclusion

In a nutshell, the journey of establishing and nurturing his sugarcane nursery has been a rewarding experience marked by dedication, resilience, and passion for agriculture. Through sustainable practices, community engagement, and continuous learning, he is confident in the nursery's potential to contribute to a brighter, sweeter future for sugarcane farming and model for today’s youngsters.

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EVOLUTION AND EXPRESSION OF ORGANELLAR GENOMES

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Introduction

Eukaryotic cells contain well defined cellular organelles such as Nucleus, Mitochondria, Endoplasmic reticulum, Golgi apparatus, Peroxisomes, lysosomes etc. In eukaryotes, DNA and genes also exist outside of the chromosomes found in the nucleus. The mitochondrion of all eukaryotes and the chloroplasts of plant cells are the only organelles that have their distinct genomes. These genomes are made of a single, circular DNA molecule denoted mtDNA in mitochondrion and ctDNA in chloroplast. The replication and the mode of inheritance of organelle genomes are distinct from the nuclear genomes.

Each organelle often has several copies of these organellar genomes. Organellar chromosomes are inherited from a single parent in the majority of sexually reproducing animals, typically the parent that generates the largest gamete. Therefore, mitochondria and chloroplasts are solely inherited through the mother (maternally) in mammals, angiosperms, and many other organisms. The chromosomes of mitochondria and chloroplasts operate differently from eukaryotic chromosomes to those of bacteria.

Organelles that can replicate themselves are mitochondria and chloroplasts. They can only be produced through the division and development of preexisting chloroplasts or mitochondria. They are not able to form from the ground up, from other organelles, or from membranes that already exist. Molecules are inserted into their membranes to support their growth.

Endosymbiont Theory

In 1905, Mereschkowsky, a Russian biologist, published a paper on the theory that photosynthetic bacteria are the ancestors of modern-day plant chloroplasts. Though this research was mostly ignored for several years, scientists came to see the similarities between isolated living bacteria and eukaryotic mitochondria. It is now largely accepted that mitochondria are descendants of "free-living" bacteria that were engulfed and incorporated as organelles by eukaryotic cells. The endosymbiont theory was further confirmed when mitochondria were discovered to contain their own DNA. It was confirmed even more so with the discovery that the mtDNA made enzymes and proteins that were needed for its own functionalities. The fact that the mitochondria also contains a double membrane also depicts the notion that it was originally a free living organism that was later ingested into another host.

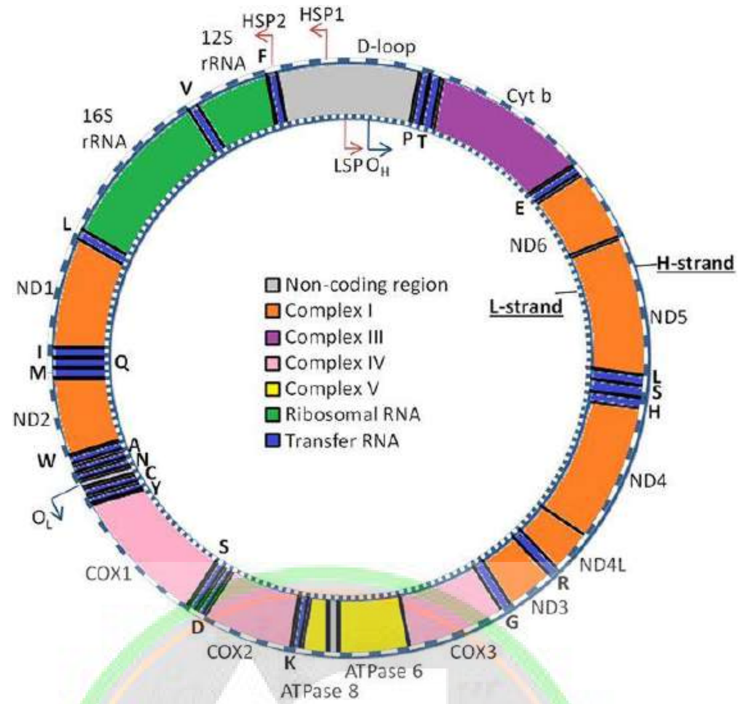
The endosymbiont theory clearly stated the followings: About mitochondria and chloroplasts

- It is enclosed by a double-membrane
- It is about the same size as bacteria
- It has its own circular DNA
- Its ribosomes are bacteria-like
- It has prokaryotic activities such as respiration and photosynthesis by mitochondria and chloroplasts respectively.

Mitochondrial DNA

Mitochondria is the powerhouse of the cell, responsible for cellular respiration by converting the energy stored in glucose into ATP. Mitochondrial DNA (mtDNA) is the DNA located in mitochondria which is a small portion of DNA than the nucleus DNA. Mitochondrial DNA is similar in appearance to that of bacterial DNA due to its circular shape. Endosymbiont theory would explain why the mitochondria had its own DNA and why this DNA is circular. Due to its own circular DNA, mitochondria DNA (mtDNA) was found to be able to self-translate and replicate itself.

Human mitochondrial DNA sequencing (1981) revealed that the human mtDNA contains 16, 569 bp and 37 genes coding for two rRNAs, 22 tRNAs and 13 polypeptides. These genes are inherited by a non-mendelian mechanism (**cytoplasmic inheritance)**.



Since animal mtDNA evolves faster than nuclear genetic markers, it represents the importance of phylogenetics and evolutionary biology. It also permits an examination of the relatedness of populations, and so has become important in anthropology and biogeography.

Genetics of mtDNA

Unlike nuclear DNA which is inherited from both mother and father, the mammalian mtDNA is only inherited from mother. The mitochondria in mammalian sperm are destroyed in the fertilized oocyte. However, the replication pathway of mtDNA is very similar to nuclear DNA. Before replication, mtDNA becomes unwind by TWINKLE, which is a protein used to undo the double-stranded DNA. After the double-stranded is undone, it is replicated at one end with the help of mtDNA polymerase. mtDNA polymerase starts to form another double-stranded starting at 5' end of the mtDNA. Another protein called mitochondrial single-stranded binding (mtSSB) helps stabilize the unwound conformation and stimulates DNA synthesis by the polymerase holoenzyme. Unfortunately, mtDNA replication displays no strict phase specificity as in nuclear DNA synthesis. Therefore, segregation of heteroplasmic mtDNA mutation can occur as a cell divides.

Mitochondrial DNA transcription

Transcriptional processes in the nucleus and mitochondria are probably comparable. RNA synthesis occurs in the nucleus and in mitochondria, however there are some distinctions between them. Guanine-rich heavy strand and guanine-poor light strand are terms given to the distinct strands of mtDNA molecules. The reason for the rarity or absence of certain codons in mitochondrial RNA can be ascribed to this nucleotide bias. The compact mammalian mtDNA genome lacks introns. The entire strand codes for either proteins, rRNA, or tRNA. Therefore, there is no need for slicing process in mitochondria. Each of the protein and rRNA genes is immediately flanked by at least one tRNA gene.

Mitochondrial genomes have several surprising features:

- **Dense gene packing**. Unlike other genomes, nearly every nucleotide seems to be part of a coding sequence, either for a protein or for one of the rRNAs or tRNAs. Since these coding sequences run directly into each other, there is very little room left for regulatory DNA sequences.
- **Relaxed codon usage.** The normal codon-anticodon pairing rules are relaxed in mitochondria, so that many tRNA molecules recognize any one of the four nucleotides in the third (wobble) position. Such "2 out of 3" pairing allows one tRNA to pair with any one of four codons and permits protein synthesis with fewer tRNA molecules. Whereas 30 or more tRNAs specify amino acids in the cytosol and in chloroplasts, only 22 tRNAs are required for mitochondrial protein synthesis.
- **Variant genetic code**. The most unexpected finding is that the genetic code differs when comparing the amino acid sequences of the relevant proteins to the sequences of the mitochondrial genes: Compared to the same codons in other genomes, four of the 64 codons have distinct "meanings."

Universal Code Vs Mitochondrial Genetic Codes

		MITOCHONDRIAL CODES			
CODON	"UNIVERSAL" CODE	MAMMALS	INVERTEBRATES	YEASTS	PLANTS
UGA	STOP	*Trp*	*Trp*	*Trp*	STOP
AUA	Ile	*Met*	*Met*	*Met*	Ile
CUA	Leu	Leu	Leu	*Thr*	Leu
AGA AGG	Arg	*STOP*	*Ser*	Arg	Arg

*Italics and color shading indicate that the code differs from the "Universal" code.

Mitochondrial Diseases

Mitochondria plays major role in aging process. Reactive Oxygen Species (ROS), are produced in greatest quantity at the mitochondria which reduces the operating capacity of the mitochondria, so this organelle is the most likely to be damaged by the free radical oxygen that may be one reason why organisms die from old age.

Mutations on the mtDNA could result in reduced ATP production, increased ROS production, and eventual apoptosis. The increased ROS production has the added affect which could cause mutation in the cell DNA. Anti-aging research has shown mitochondria life span has been increased by low ROS production that results less damage. Specifically, a reduction in the mitochondrial function of the electron transport chain (ETC) in *Caenorhabditis elegans* increased longevity of the organism.

Researchers are hoping to use this to lengthen human longevity by combining dietary restriction (DR) with a reduction in mitochondrial activity. Cellular processes would shift such that the focus is on sustaining current cellular structures rather than creating new structures to replace old structures by lowering the amount of calories consumed, but not to the point of starving. As a result, cells would stay in the body longer and undergo fewer mutations as a result of gene replication during mitosis. A number of inherited diseases in humans are observed due to mitochondrial mutations.

- Homoplasmic mutant cells (with only mutant mito genomes) are unable to do aerobic respiration, so they die.
- Heteroplasmic cells survive, but have reduced respiration -> defects in tissues requiring high level of respiration, e.g. muscle, eye.

Some examples of Mitochondrial Diseases

- Fatal infantile mitochondrial myopathy and renal dysfunction
- MELAS(mitochondrial encephalopathy, lactic acidosis and stroke).
- Lebers hereditary optic neuropathy
- Myoclonic epilepsy
- Ragged red fiber disease

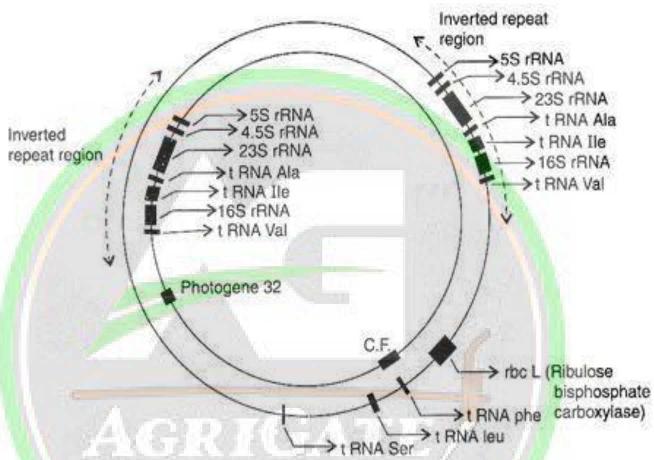
Symptoms:

Muscle weakness and pain, gastrointestinal disorders, swallowing difficulties, poor growth, fatigue, poor balance, cardiac disease, liver disease, diabetes, respiratory complications, developmental delays, skeletal muscle abnormalities, and susceptibility to infections, nervous system impairment etc.,

Chloroplast DNA

Photosynthesis is carried out by the organelles. They convert NADP to NADPH and store free energy as ATP by absorbing light energy. One or more tiny, circular DNA molecules would be found in the stroma, the substance that makes up the chloroplast. Photosynthesis is carried out in stacks of thylakoids found within the stroma. Grana are the stacks composed up of thylakoids. The thylakoid space, also known as the lumen, is an empty space found inside a flattened disk-shaped thylakoid. Photosynthesis occurs on the thylakoid membrane, which is made up of proteins that bind the pigments and pigments that absorb light, like carotenoids and chlorophyll.

Maize cpDNA



There are roughly 120 genes in the chloroplast genome of higher plants. At present, around 20 genomes of chloroplasts have been sequenced. Even closely related plants like liverwort and tobacco have almost identical genomes, as do closely related green algae. Four primary processes involving chloroplast genes are transcription, translation, photosynthesis, and the synthesis of tiny molecules like pigments, fatty acids, and amino acids. Plant chloroplast genes also encode at least 40 proteins whose functions are as yet unknown; in addition, about twice that many genes of unknown function are present in the chloroplasts of some algae.

Further comparisons of large numbers of homologous nucleotide sequences should help clarify the exact evolutionary pathway from bacteria to chloroplasts, but several conclusions can already be drawn:

1.Chloroplasts in higher plants arose from photosynthetic bacteria.

2.The chloroplast genome has been stably maintained for at least several hundred million years, the estimated time of divergence of liverwort and tobacco.

Summary

Two distinct genetic systems—one in the organelle and one in the cell nucleus—are necessary for the harmonious development of mitochondria and chloroplasts. The majority of the proteins found in these organelles are synthesised in the cytosol, transported one at a time into the organelle, and encoded by nuclear DNA. The DNA of the organelle codes for certain proteins and RNAs that are synthesised within the organelle. About 120 genes are found in chloroplast genomes, which are roughly ten times larger. Genetic codes found in mitochondria always deviate from universal codes.

The close resemblance between the ribosomes of bacteria and chloroplasts, as well as the similarities between their proteins, indicate that both organelles evolved from a primitive eukaryotic cell that formed a stable endosymbiotic connection with a bacterium. The mitochondrion is supposed to have originated from a purple bacteria, while the plant chloroplast is thought to have originated from a cyanobacterium. The majority of these old bacteria's genes have integrated into the nuclear genome, where they encode enzymes like those of bacteria that are synthesised on cytosolic ribosomes before being imported into the organelle, despite the fact that many of their genes still function to produce organelle proteins.

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INTEGRATED FARMING SYSTEM: OBJECTIVES, CHARACTERISTICS. COMPONENTS AND ADVANTAGES

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Abstract

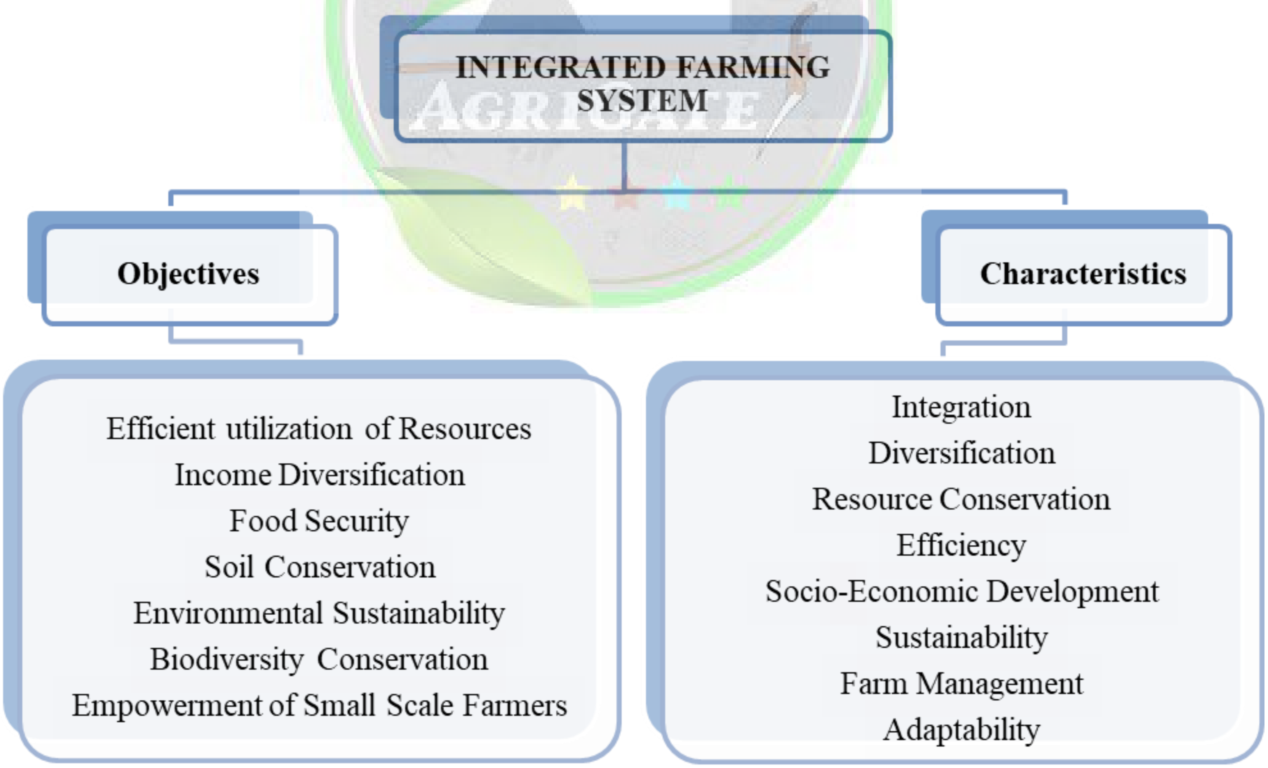
The serious challenges faced by our country are the fragmentation and decline in the agricultural lands affecting the sustainability and profitability of the farm holdings. This is posing a major threat to the food and nutritional security. The famers are facing financial losses due to the adoption of any single farming enterprise which has higher chances of loss due to crop failure or price volatility. Integrated farming system is the integration of various farming enterprises helps to achieve sustainability and profitability in the fragmented and declining agricultural land holdings. Integrated farming system can be adopted for its benefits like effective and maximum utilization of resources available in the farm, diversified sources of income through integration of various farming enterprises and sustainable agricultural production without causing any threat to the environment. Hence the practice of integrated farming system in the small land holdings would be beneficial if managed well.

Keywords: Integration, Farming systems, Sustainability, Profitability

Introduction

The integration of different farming systems like agriculture, livestock, poultry, apiculture, aquaculture, horticulture, agroforestry and mushroom cultivation in a single farming system is known as Integrated Farming System (IFS). The IFS aims to develop the sustainable farming systems for the small scale farmers in the rural areas to increase the productivity with low costs in the developing countries. Integrated farming system has the potential to balance the environment and improve the socio-economic conditions of the farmers. Integrating different components with crops will increase the profitability through recycling wastes of one component into another[1]. The proper selection and integration of different components improves soil fertility, increases food security and diversifies the sources of income which helps in the overall well-being of the farmers.

The various farming systems and their integration depend on the soil type and climatic conditions of the region. The availability of essential resources must be kept in mind for the successful adoption of integrated farming system. The efficient utilization of available natural resources must be done on a sustainable basis with minimum degradation. The farmers should have a positive approach towards the profitable new technologies created. The skill of the farmers to handle and manage the farming systems is important to safely implement integrated farming system and generate continuous flow of income round the year. It can be a viable option for the livelihood security of small and marginal farmers[2].



Objectives of IFS

1. Efficient utilization of resources: The integration of different components helps in the utilization of waste product of one component as a resource in another component and helps in the effective utilization of resources.

2. Income diversification: IFS diversifies the sources of income to the farmers due to its integration with various components like agricultural crops, livestock, poultry and aquaculture. It reduces the risk of crop failure.

3. Food security: IFS helps to increase the food production by promoting sustainable agricultural practices to feed the ever increasing population and reduces food insecurity.

4. Soil conservation: IFS conserves the soil by adopting different cropping systems like crop rotation and intercropping. This improves the soil quality and conserves it from soil erosion and other forms of soil degradation.

5. Environmental sustainability: IFS employs good agricultural practices by reducing the intensive application of chemical fertilizers, pesticides and fungicides. It reduces the accumulation of toxic pollutants and emission of green house gases safeguarding the environmental sustainability.

6. Biodiversity conservation: IFS like agro forestry creates biodiversity in the farms and conserves the habitats of flora and fauna.

7. Empowerment of small scale farmers: IFS adopts sustainable agricultural practices and empowers the small scale farmers by improving the productivity of various components and finally their income.

Characteristics of IFS

1. Integration: IFS aims in the integration of different components like crops, livestock, forestry, apiculture, horticulture and aquaculture.

2. Diversification: IFS involves growing of different crops, rearing of different livestock like cow, sheep, and goat and integrating it with apiculture and aquaculture.

3. Resource conservation: IFS helps in the conservation of various natural resources like soil and water by improving the agricultural practices like application of organic manures and crop residues, adopting crop rotation, intercropping and good irrigation systems.

4. Efficiency: The efficiency in the usage of natural resources, nutrients and water is employed in integrated farming system.

5. Socio-economic development: The diversity and integration of different components of farming systems will increase the income of the farmers with the diversifying sources of income and improve their socio-economic conditions.

6. Sustainability: IFS aims to achieve the sustainable way of farming with efficient utilization of resources by safeguarding the environment.

7. Farm management: Since the integrated farming system involves the integration of various components it is essential to go for proper planning and management of activities in the farm and ensure effective utilization of farm resources.

8. Adaptability: Depending upon the local conditions of the farming systems IFS can be adapted to various agro climatic zones.

Factors to be considered while implementing IFS

- Assessment of local conditions of the farm like rainfall and its distribution, temperature, humidity, length of the growing period and soil type.
- The availability of necessary resources to the farmers.
- Social customs and economic conditions of the local farmers.
- Selection of various components and their integration must be done with upmost care based on the availability of resources and agro climatic conditions. The proper selection of suitable crops, livestock, aquaculture, apiculture and other components must be made.
- Selection of appropriate agricultural practices like intercropping and crop rotation with cereals, pulses and vegetable crops.
- Proper planning, implementation and monitoring of the IFS should be carried out.

Components of IFS

- **Crops:** It involves the selection of various crops like cereals, pulses, oil seeds, vegetables, fruits and forage crops.
- **Livestock:** It includes rearing of different types of livestock such as cows, buffaloes, goats, sheep and poultry.
- **Aquaculture:** It refers to rearing of fishes.
- **Apiculture:** It refers to the rearing of honey bees for honey, bee wax and other products
- **Agroforestry:** It is the integration of agriculture with growing trees for timber, fuel, fruits and fodder.

Advantages of IFS

- **Productivity:** IFS improves the productivity of crops and other enterprises involved with proper integration and management.
- **Diversified sources of income:** The integration of various components creates many sources of income to the farmers and reduces the cost of production[3].
- **Improved soil fertility:** IFS helps to increase the soil fertility by improving the soil physical, chemical and biological properties and preventing soil erosion and degradation[3].
- **Balanced food:** IFS ensures balanced nutrition in the diet of the farmers[2].
- **Efficient use of natural resources:** IFS initiates efficient use of natural resources available at the farm.
- **Sustainability:** IFS promotes the integration of different farming systems on sustainability basis.
- **Recycling:** The waste products produced in the farming systems are effectively recycled in IFS.
- **Conservation of natural resources:** IFS promotes the conservation of natural resources like soil and water and renders it to the future generations in a safe way.
- **Generation of employment:** IFS generates employment as it would increase the requirement of labour due to the integration of various components.

Conclusion

The practice of integrated farming system will be profitable with the selection of appropriate selection of components and keeping in view of the agro climatic conditions of the farming system. It can be a good solution to the challenges faced by the farming community through conventional agriculture practices. Integrated farming system ensures improved soil fertility, efficient use of resources, diversified income and enhances food security. Therefore its adoption had to be intensified to cope up all the issues facing by the farmers.

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INTEGRATED MANAGEMENT FOR FALL ARMY WORM IN MAIZE

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Abstract

Fall Amry Worm, *Spodoptera frugiperda* is found to be an important invasive pest of maize. This study was conducted to evaluate the performance of TNAU refined integrated pest management capsule for the management of Fall Amry Worm in Tiruvallur district. Farmers who grow maize were selected randomly and demonstration was in ten places. The results revealed that FAW incidence of 11.40% and 12.62% of leaf and whorl damage was recorded against 24.58% and 23.40 % leaf and whorl damage in Farmers' practice. With reference to cob damage, minimum level of incidence of 12.62 % was observed against 37.60 % in Farmers' practice plot. Yield increase of 45.90% over farmers' practice due to reduction in pest incidence with net income of Rs.43730 with BCR of 2.9. Hence, Refined IPM capsule was well accepted by the farmers and performed well at Tiruvallur district against Fall Army Worm incidence in Maize.

Key Words: *IPM capsules, Fall Army worm in Maize, Tiruvallur*

Introduction

In India the incidence of Fall Amry Worm, *Spodoptera frugiperda* pest was detected during 2018 in Maize fields at Shivamogga (Deole, 2018). There after it made its appearance in six other states of the country, including Tamil Nadu, Andhra Pradesh, Odisha, Chhattisgarh and Gujrat. Their spread alarming and has raised a national concern all over. Fall Amry Worm is polyphagous in nature with more than 85 host species. They are responsible for leaf damage along (Bessin, 2019) and major damage is done by younger larvae. Mainly young larvae they feed on leaf tissue making hole on them which is typical symptoms of this pest (Sesay *et al*., 2019). Generally feeding on the young plant by fall armyworm through whorl may lead to dead heart. Older larvae can cause greater damage and defoliation leaving only ribs and stalk of corn plant giving torn or ragged appearance (Capinera, 2017). In Tiruvallur district, Maize is being cultivated in 20 to 25 hectares of area during Kharif and Rabi season. Maize crop was observed to be affected by fall army worm *Spodoptera frugiperda* incidence. Integrated pest management (IPM) is the one of most preferred and effective management of fall armyworm (Day *et al*., 2017). Hence it was proposed to conduct frontline demonstration on TNAU refined IPM capsule for Fall Army Worm management in Maize in Tiruvallur district.

Materials and Method

The main objective of the study is to demonstrate recently standardised crop protection technology, as well as their management practices, in a farmer's field. InTiruvallur district, demonstration on TNAU refined IPM capsule for FAW management I maize was conducted in ten places of farmers' field at Avichery and Thirukananjeri villages during 2020-2021. Farmers were provided with major critical inputs and trainings were conducted to familiarize and popularize the technology among the farmers. The TNAU refined IPM capsule includes the application of neem cake @ 250 kg/ha at the time of last ploughing; Seed treatment with cyantraniliprole 19.8% +thiamethoxam19.8% FS @ 4 ml/kg seed; Border cropping with cowpea, gingelly/ redgram or sunflower; pheromone traps @ 12/ha; Window based application of insecticides – during Early whorl stage (15 – 20 DAE): application of Chlorantraniliprole 18.5 SC @ 0.4 ml/ lit (or) flubendiamide 480 SC @ 0.5 ml/lit followed by azadirachtin 1500 ppm @ 5 ml/lit on need basis and during Late whorl stages (35-40 DAE): application of Emamectin benzoate 5 SG @ 0.4 g/lit or novaluron 10 EC @ 1.5 ml/lit or spinetoram 11.70 SC @ 0.5 ml/lit and during Tasseling and cob formation stage (only if required) spraying of Spinetoram 11.70 SC @ 0.5 ml/lit (or) emamectin benzoate 5 SG @ 0.4 g/lit (which was not sprayed at late whorl stage). Fortnight observation on leaf damage, whorl damage, tassel damage, cob damage and also natural enemy complex *viz*., spiders, and coccinellids in the demo trials, farmers' practice plots and untreated check plots were recorded and mean damage symptoms were arrived and analysed with one way Anova.

Results

Front line demonstration on refined IPM capsule for Fall Army Worm (*Spodoptera frugiperda*) management in Maize was conducted in ten places at Avichery and Thirukananjeri villages of Tiruvallur district. The farmers were facilitated with critical inputs and fortnight observation on leaf damage, whorl damage, tassel damage, cob damage and also natural enemy complex viz., spiders, and coccinellids in the trials, farmers' practice fields and untreated check plots were recorded from July to December and mean damage symptoms were arrived and analysed. In refined IPM plots, *Spodoptera frugiperda* incidence of 11.40% and 12.62% of leaf and whorl damage was recorded against 24.58% and 23.40 % leaf and whorl damage in Farmers' practice. With reference to cob damage, minimum level of incidence 12.62 % was observed in refined IPM plots against 37.60 % in Farmers' practice plot. Occurrence of natural enemies in IPM plot was 0.75 numbers plant as against 0.45 numbers per plant. Maximum yield was recorded in refined IPM plots of 4.45 t/ha against farmers practice with 3.05 t/ha. Net income of Rs.43730 with BCR of 2.9 was recorded in refined IPM capsule plots against farmers' plot with the net income of Rs.20700 with BCR of 1.8 (Table 1.).

Table 1. Performance of refined IPM capsule for Fall Army Worm in Maize

Treatments	Yield t/ha	Net Income (Rs./ha)	Leaf damage %	Whorl damage%	Cob damage%	BCR
FAW -Refined IPM capsule	4.45	43730	11.40 (19.54)	12.62 (20.67)	8.61 (16.78)	2.90
Farmers' Practice	3.05	20700	24.58 (29.63)	23.39 (28.81)	37.6 (37.71)	1.80
Untreated Check	1.82	17900	42.50 (40.67)	37.50 (37.66)	52.4(46.41)	1.10
SED	0.186	1187.69	1.308	0.935	1.838	
CD (0.01)	0.391	2495.5	2.748	2.777	3.861	

Hence yield increase of 45.90% over farmers' practice due to reduction in pest incidence was recorded. Refined IPM capsule was well accepted by the farmers and performed well at Tiruvallur district against Fall Army Worm incidence in Maize. The Front line demonstration intervention is highly effective among maize farmers with increased net returns due to reduced FAW incidence. Hence, FLD plays a vital role in dissemination of technology on a community basis when compared to other approaches

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HARVESTING THE GREEN GOLD: EXPLORING THE AGRICULTURAL POTENTIAL OF SEAWEED

Article ID: AG-VO4-I04-33

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Abstract

Seaweed, often referred to as "marine vegetables," holds immense potential as a sustainable and lucrative agricultural resource. This article delves into the burgeoning field of seaweed cultivation, exploring its vast agricultural possibilities and environmental benefits. With the increasing demand for food, fuel, and eco-friendly products, seaweed emerges as a promising solution to various global challenges, including food security, climate change mitigation, and marine conservation. By examining the diverse applications of seaweed, from food and biofuel production to bioremediation and pharmaceuticals, this article sheds light on its versatility and economic viability. Furthermore, it investigates the advancements in seaweed farming techniques, highlighting innovative approaches that maximize yield while minimizing environmental impact. Through case studies and expert insights, readers will gain a comprehensive understanding of the green gold hidden beneath the ocean's surface and its potential to revolutionize agriculture and sustainability efforts worldwide.

Introduction

Seaweeds are algae, specifically, they are macroalgae and despite performing many of the same functions as plants they are not plants. Because of this, seaweed is frequently referred to as non-vascular plants (Khan *et al.*, 2009). However, in contrast to plants, these species directly absorb nutrients through their cell walls, allowing them to perform photosynthesis (Strik *et al.*, 2004). They also lack many other specialised plant structures, including as xylems, roots, and stems. Seaweeds can be divided into three main groups: green, red, and brown. Each species unique combination of chlorophyll and other accessory photosynthetic pigments gives these groups their colour. For instance, red seaweeds have pigments called phycoerythrin and phycocyanin that help them absorb light that penetrates deeper into the ocean, while brown seaweeds have fucoxanthin (Craigie *et al.*, 2011). People have historically used seaweeds for a variety of purposes, including therapeutic purposes. More recent studies have identified the precise components in seaweeds that enable these functions. Some of the roles of seaweeds in general include:

Food (healthy low calorie)	Medicine	Edible packaging	Dyes
Fertiliser	Supplementary livestock feed	Bioethanol	Gels
Climate change reduction	Medicine	Cosmetics	Edible packaging
Explosives	Plant biostimulants	Bio yarn	Bioremediation

However, the most interesting roles in agriculture are those that are highlighted

Seaweeds and agriculture

The 1992 journal article "Seaweed extracts in agriculture and horticulture: a review" has been mentioned nearly 350 times in subsequent works, indicating the high degree of interest in seaweeds and seaweed extracts for use in plant growth and agriculture. However, the advantages of seaweeds were mentioned in customary historical practices of coastal agricultural groups prior to these scientific viewpoints (Ali *et al.*, 2021).

This included the use of beach-cast seaweed as manure and fertiliser for the land, dating back to Roman times, and the grazing of harvested seaweed for livestock as an additional food source. Invasive algae have a major impact on freshwater and marine ecosystems, in addition to native macroalgae species that are essential. Chami *et al.*, 2020 states that when human activity affects marine environments and streams, it frequently results in eutrophication, a condition where an excess of nutrients promotes the growth of algae and the invasion of non-native species. For ecosystems to return to normal, these higher amounts of algae must be collected and removed; using this "waste" could enable some environmentally conscious circularity. Though of course, this circularity is finite if agriculture and other water pollution sources are targeted for reduction and removal in the long run.

Direct fertiliser and land application

In most cases, seaweeds are applied to land in whole, finely chopped, powdered, or aqueous extract forms.

Benefits

A variety of potential applications for seaweed (or its extracts) in agricultural and horticultural systems are reported when they are added as a soil addition or fertiliser. Like other green manures, it can serve as an effective carbon-neutral fertiliser component. Arioli *et al.*, 2015 although, thought to have less phosphorus (P) and nitrogen (N), seaweeds do have a tendency to contain more potassium (K). Despite seaweeds have hormones that cause plants to grow and absorb nutrients more efficiently, they can also act as plant biostimulants by directly adding plant rate-limiting components to soils. Hernández-Herrera *et al.*, 2022 revealed that Seaweeds contain several compounds that can affect plant growth, ageing, cell division, germination, and stress management, including auxins, cytokinin, gibberellins, ethylene, and abscisic acid.

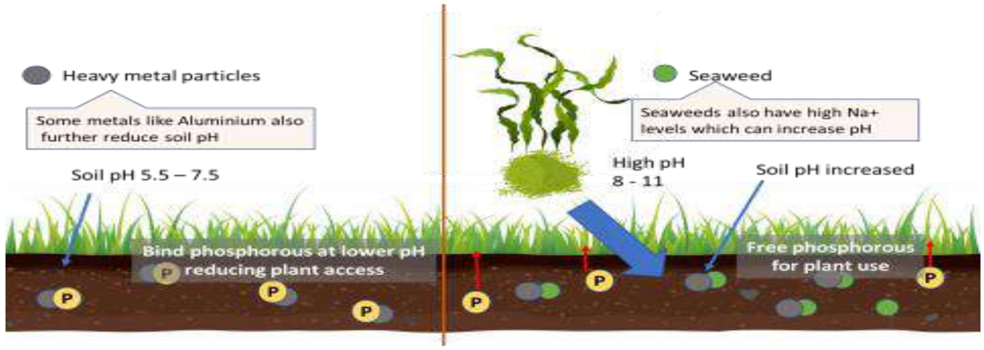
Many research point to positive results, even though there aren't many meta-analyses comparing the effects of various macroalgae applications on crop yields and nutrient requirements.

Crop	Positive impacts	Paper
Marigolds	~40% increase in flower weight 50% less chemical fertiliser required	Sridhar & Rengasamy (2010)
Tomato seedlings	Increased plumule length, radicle length, increased dry weight, increased shoot length and plant height, worked better as soil amendment than foliar spray	Hernández-Herrera *et al* (2013)
Bean	Increased germination	Carvalho *et al.* (2013)

Broccoli	Increase in antioxidant activity, flavonoids, phenolic and isothiocynate, increases in stem diameter, leaf area, biomass, enhanced early growth and reduced white blister (Albugo candida)	Mattner *et al.* (2013)
Mung Bean	Increase in total protein, total carbohydrate and, total lipid; increase in shoot and root length	Ashok Kumar *et al.* (2012)
Watermelon	Increase in yield	Abdel-Mawgoud *et al.* (2010)
Onion	Increase in yield and reduced severity of downy mildew	Dogra and Mandradia (2014)

Research indicates that green macroalgae has the most potential for soil supplementing among the three categories of seaweed because they include elements that can encourage the clearance of harmful soil and plant fungi and diseases (such moulds and mildews) and foster greater plant defence (Hussain *et al.*, 2021). Additionally, it has been demonstrated that they may play a part in mitigating crop damage caused by some plant nematode species. This could make them a special organic substitute for nematicides that are administered to the soil (Begum *et al.*, 2018). It is well known that seaweed and its byproducts, such as charcoal, have a neutral to alkaline pH, which when applied directly to soils, can modify the pH of the soil and act as a liming agent. Additional results linked to the liming function observed in seaweed studies include elevated sodium (Na+), calcium (Ca), and alginate levels, all of which contribute to the seaweed's capacity to bioaccumulate heavy metals. By preventing soil particles that would typically cause increased acidity from entering the soil, the removal of metals can have an effect on pH. Applying seaweed to contaminated, degraded land may also aid in the removal of heavy metals like aluminium (Al), which will prevent or lessen Al's capacity to bind to nutrients that are essential to plants, such as phosphorus. This could in certain systems further help to reduce fertiliser requirements (Mukherjee *et al.*, 2020, Egan *et al.*, 2013).

Moreover, one of the frequently mentioned characteristics of commercial seaweed additives is that their alginates affect the structure of soils by creating complexes that aid in water absorption, enhancing water retention, raising aeration and soil pore functionality, and generally enhancing soil structure (Brown *et al.*, 2014).



This relates to the interest in applying hydrogel to soils for the special benefits of slow-releasing fertilisers and higher soil moisture levels around plants.

Barriers to use

In a few instances, seaweed biomass requires additional supply chain and market considerations. Direct site-based production and subsequent use are necessary to prevent the material from fermenting and degrading and turning into another type of waste that may have negative effects, such as the release of harmful gases like hydrogen sulphide. Composting is one way to stop this nutrient waste and maintain the advantageous properties of seaweeds (Khan *et al.*, 2009). In one series of tests, it was discovered that high seaweed composts produced four times more aboveground biomass than commercial composts devoid of seaweed when green seaweeds composted with sugarcane wastes were reapplied to subsequent sugarcane growth. Benefits in the levels of micro and macro elements (such as boron, iron, copper, zinc, calcium, sulphur, and potassium) were observed within the plant biomass harvested, even in instances where minor affects on biomass weight and yield occurred. When introduced to soils under anaerobic conditions (*i.e.*, unoxygenated soils), high concentrations of sulphur compounds found in certain seaweeds may work against the soil's ability to liming because microbial oxidation of sulphur to sulphates can occur (Rayorath *et al.*, 2009).

Feed for methane reduction

Another area in which seaweeds have drawn a lot of interest from the agricultural community is their potential applications as animal feed. The environmental effects of these applications have been the subject of extensive research and media coverage.

Benefits

Certain seaweeds have a high protein content (up to 47% of their weight), while others include healthy amounts of omega-fatty acids. They are attractive as a potential substitute protein source for cattle because of their high protein content. It is simple to understand the curiosity when one considers the existence of naturally occurring chemicals in seaweeds that influence the creation of methane. It is believed that seaweeds work primarily through the inhibition of the last stage of methane generation caused by rumen microbes. This is achieved by the presence of bromoform in seaweeds. It is known that red seaweed species have larger quantities of bromoform and comparable functional levels of bromochloromethane. Studies have shown methane reductions of up to 100% (during short study periods) and 98% (over longer 90-day timeframes) (Raj *et al.*, 2018). Conversely, other studies have reported far lower decreases or, in a few instances, slight short-term increases in methane levels. Future net-zero methods will likely be very interested in the environmental effects of seaweed as feed, thus there will probably be more research done in the future to attempt and sort through these contradicting findings through large-scale experiments. Other feed effects that have been documented include reductions in dry matter ingestion and improvements in live weight gain in addition to methane implications.

Obstacles to Adoption

Seaweed is highly good at accumulating heavy metals, as mentioned above in the benefits of seaweed for fertiliser and soil application. This is also true in aquatic habitats prior to harvest. Because of this, care may need to be taken while evaluating and obtaining seaweeds for livestock consumption to make sure that any rations do not result in significant amounts of harmful metals entering the animal's body. Similar to this, the use of seaweed in feeds may be hampered by the toxicity of iodine to cattle as well as its assimilation into meat and milk. In one experiment, high iodine levels in seaweeds were found to produce milk with iodine levels as high as 3 mg/L (Battacharyya *et al.*, 2015). This means that the safe daily limit of milk for adults is approximately 300 ml, and for children, 1 litre of milk would contain more than 15 times the recommended tolerable level. Even though this is only one study, it is sufficient to suggest that additional research might be needed. An additional potential obstacle to seaweed application in cattle nutrition could be the suggestion that its low palatability causes problems with feed intake. Even while inclusion rates in sheep trials have been reported to reach 20% in some studies, the average inclusion rate (across more than ten investigations) was 12.8% (with 0.006% as the lowest). Certain seaweed extracts may work better in this situation than the product as a whole (Illera-Vives *et al.*, 2020).

Further thoughts about seaweed

The potential utility of seaweed as a substitute for fossil fuels that harm the environment is a major factor in seaweed utilisation. For a number of reasons, seaweeds present an intriguing alternative for biomass growth in the generation of biofuel. First off, seaweed biofuel would be nearly carbon neutral, just like plant-based biofuel alternatives. Not only do they exhibit encouraging biomass output levels and cost-effective growth, but they also don't directly compete with agricultural land application or alter land usage. This is crucial. This means that the food vs. fuel argument cannot be used to support the claim that it would be preferable to produce something else in place of seaweed.

This function might, however, directly compete with other roles for the supply of macroalgae for agricultural uses unless excess was generated or techniques were refined to efficiently and economically separate the biomass used for biofuel from the agriculturally significant chemicals. Moreover, direct seaweed farming throughout Europe would be necessary to make seaweed inclusion practicable on a wide scale and prevent related import problems. Numerous studies have indicated that seaweed farming at such scales would probably have an impact on biodiversity; however, the precise nature of these effects is still unknown, with some demonstrating minimal effects and others demonstrating a decline in fish species biodiversity as a result of disturbances. Before safely achieving large-scale supply, considerably more focused experimentation would be needed. Seaweed farming and artificial growth is a rapidly expanding field in aquaculture, with estimates indicating that it contributes approximately 27% of all marine aquaculture production. Even yet, it's evident that a great deal more study and development is required to determine which species to cultivate and how best to do so in the UK in order to have enough resources for a larger-scale integration into agriculture. Since seaweed is now farmed mostly in Asia, import and export considerations are quite important. Seaweed farming has a bright future because its growing methods don't compete with arable land or freshwater aquaculture, and their expansion has been connected to carbon reduction initiatives.

Other economic and environmental benefits could result from the removal of seaweed for use in agriculture. Large-scale beach casting of seaweeds is sometimes linked to detrimental effects on tourism because of the way the material looks and smells as it ferments. This is one way that this could be advantageous. The local economy of coastal places could therefore benefit from having systems in place to harvest this seaweed for advantageous agricultural uses or any other useful applications. The direct roles that seaweed-derived chemicals play in infection control and biocidal actions have already been covered. However, there is also interest in chemically modifying these substances to achieve better results; a lot of research indicates that these modifications may have intriguing antibacterial functions. In the end, they might contribute to bettering livestock treatment choices and lessening the effects of antibiotic resistances, which are still a worry for the sector.

Conclusions

The agricultural usage of seaweed and macroalgae may contribute to circularity, especially in coastal areas or where farming practices exacerbate eutrophication of adjacent water sources, which results in increased development of macroalgae in waterways. It could be better to harvest this and reapply it to agricultural soils or feeds rather than letting it affect ecosystems. Seaweed supply chains must be taken into account when applying seaweed to soil in order to fully understand the logistics and cost-benefit ratios (both environmental and economic). Moreover, it seems that seaweed functions better in healthier soils with methods in place to lower anaerobic microbial activity levels. This implies that it would be a good fit when combined with environmentally friendly techniques like cover crops and silvic-arable farming. However, macroalgae for animal feed have intriguing environmental effects and the potential to be a viable substitute source of protein; large-scale trials are needed to further assess this. Red seaweed species are more promising for usage with animals, preventing conflict between these two goods. Green seaweed species are promising for application in soil.

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FARMING SYSTEMS IN AGRICULTURE

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Abstract

Farming systems vary widely across the globe due to factors such as geography, climate, culture, and technological advancements. This abstract provides an overview and comparative analysis of different types of worldwide farming systems. Conventional farming, rooted in industrialisation and modern agricultural practices, relies heavily on chemical inputs, mechanisation, and monoculture cropping systems to achieve high yields and economic efficiency. In contrast, organic farming avoids fertilisers and pesticides. In the case of agroforestry, it integrates trees along with crops.

Keywords: *farming systems; agriculture; sustainable agriculture*

Introduction

Farming systems refer to the combination of the various components such as crops, livestock and other farming systems practices used by farmers to achieve their production goals. It is a decision-making unit comprising farm households, cropping systems, fisheries, livestock and poultry systems that transform land, capital and labour into valuable products that can be consumed or sold. Farming systems are essential for food production in the rural livelihood since 58 per cent of the rural community depends on agriculture. These systems ensure food security and help conserve and manage natural resources such as land, water, and biodiversity. It has a vital role in climate change mitigation and helps reduce disease and pest attacks to a certain level. This holistic concept is very relevant during these times because even though the population is increasing, there is no scope for the horizontal expansion of the land.

Types of Farming Systems

Indigenous farming system

Shifting Cultivation

It is an old antique farming system practised in the sloppy areas of the Northeastern states and called slash-and-burn agriculture. It is believed to have originated in the Neolithic era around 7000 years ago. Shifting cultivation is a famous system in India and other countries in Asia, Africa, and Australia. Shifting cultivation is locally called Jhum, Podu, Pothu, Penda, etc., in India. In this, cultivation is practised for a few years. Then, the area is abandoned, while post-disturbance fallow vegetation is allowed to grow freely, and cultivators move to other locations. The fallow period was 10-20 years earlier, and now it is reduced to 2 – 5 years. The primary function of the fallow is to maintain soil fertility and reduce soil erosion.

Taungya cultivation

Taungya (hill), ya (cultivation) and this system originated in Myanmar. During the 1980s, this system was introduced in the Chittagong and Bengal areas. It includes growing arable crops along with the forestry species during the early period of forest establishment.

Zabo cultivation

Zabo is an indigenous system practised in the Phek district of Nagaland, which means Impounding water. It is also called the theruze system. Rainwater is collected from the protected hilltops' catchments, which are used for paddy cultivation. It combines forest, agriculture, livestock, and fisheries with definite soil and water conservation practices.

Subsistence farming

Small-scale farmers practise this farming system for consumption, and no extra products are produced. The main features are that the whole family works on the farm, and all the work is done manually. Under this farming system, farmers use traditional tools and implement them for cultivation. They mainly depend on rainfall to cultivate their land; sometimes, they irrigate the land with water from ponds or other local reservoirs. They manage to procure all the agricultural needs with their efforts. The subsistence farming method is found in the small patches of some underdeveloped regions or remote valleys of Asia where the line of communication is detached from the outside world due to the problematic valleys scattered over mountains, etc.

Conventional Farming System

The system, also known as traditional farming, generates products with an economic orientation using synthetic chemicals and pesticides, and minor consideration is given to environmental safety. The main aim is to maximise the yield and thus enhance the profits.

Organic farming systems

Organic farming relies on compost, organic manures, and liquid manures to cover crops, enhance soil fertility, and control pests and diseases. It avoids the use of the agrochemicals and other inputs. A principal component of organic farming is very effective in enhancing soil fertility and crop growth. The main components are crop residue (cop residues obtained from the farm are very effective in recycling the nutrients), Crop rotation and organic manure (obtained from different plant materials, animal-human and fish manures, etc. Crop growth may improve through organic farming directly by improving the uptake of biological sources and indirectly increasing soil fertility by enhancing the availability of major and minor plant nutrients through soil microorganisms (Santhosh Kumar et al., 2017; Agera et al., 2019)

Agro-ecological farming system

It is based on the concept that agricultural practices are site-specific and dependent on socioeconomic conditions. By fostering synergies between crops, livestock, and natural resources, agroecology promotes diversified farming landscapes, soil fertility, and ecosystem services, contributing to food sovereignty and resilience against climate change.

Agroforestry

A type of farming system involves the integration of the trees and the crops. When properly applied, agroforestry can improve livelihoods through enhanced health and nutrition, increased economic growth, and strengthened environmental resilience and ecosystem sustainability. In turn, such improvements can contribute to increased social sustainability in which human needs are satisfied in a way that fosters ecological health. Agroforestry systems also yield proven strategies for long-term carbon sequestration, soil enrichment, biodiversity conservation, and air- and water-quality improvements, benefiting the landowners and society.

Bio-intensive organic farming

Bio-intensive farming is the organic system of growing crops focusing on the maximum yield from the minimum area using no fertilisers or pesticides. In the long term, sustainability is the goal. This method is inexpensive and can be easily implemented, so it will be helpful for those who need more area and resources.

Natural farming

It reflects the experience and philosophy of the Japanese farmer Masanobu Fukuoka based on the five principles: no fertilisers, no tillage, no pesticides, no weeding or pruning.

Permaculture

The term is the fusion of the permanent and cultivation. In permaculture, plants are grown in diverse mixtures of perennial and annual plants that provide food for one another. This helps to increase soil health, removing the need for pesticides, herbicides, and chemical fertilisers. The result is crop growth at the pinnacle of organic farming.

Commercial farming

It encompasses the extensive cultivation of crops with the primary objective of exporting these products to other countries. I mainly followed in the regions of Punjab, Gujarat and Maharashtra.

Integrated farming

Integrated farming combines different farming enterprises such as livestock, poultry, sericulture, and aquaculture to enhance productivity and fulfil economic and ecologic demands. These systems have many more benefits: they help to improve soil fertility, provide employment opportunities, empower rural communities and strengthen community resilience.

Specialised farming

This farming system mainly focuses on the single cropping system or farming enterprise like animal breeding, dairying, etc, to achieve the highest degree of precision management. More than 50% of the income comes from a single activity. The main aim of this farming is to generate more revenue.

Based on the water supply

Irrigation farming

These farming systems depend on irrigation water and are practised in areas with an annual rainfall greater than 750 mm. In this concept, moisture is achieved by growing drought-tolerant crops like bajra and jowar, which require less water.

Rainfed farming

Type of farming system which relies on the rainfall. They are primarily practised in areas with an annual rainfall of 1150 mm. The significant advantage of these farming systems is that they do not require installing or maintaining irrigation structures.

Based on the type of rotation

Ley system

In this system, several years of arable farming are followed by arable crops, followed by several years of grasses and legumes for livestock production. Ley farming is economical for rainfed farmers as they need not invest much in nitrogen fertiliser input plants for food grain crops but can depend on the nitrogen built up by pasture legumes.

Perennial cropping system

The crops that covered the land for many years were grown, such as tea, coffee, sugarcane, etc. Perennial tree crops like oil palm and rubber are also included in some cases. Compared with annual crops, perennial crops have extensive root systems, making soil particles challenging to dislodge and limiting soil erosion. Erosion is further reduced by the limited tilling needed to maintain the crop.

Based on the enterprises

Single enterprises

This type of farming enterprise can be easily identified and disaggregated from a whole farm system like a tea estate or coffee estate.

Composite enterprise

This system aggregates two or more different systems into a single composite enterprise. A typical Peshawar farm consists of two cows (providing ghee and milk mainly focused on consumption), two oxen (for ploughing), three young cattle, one camel for transport, and six sheep for wool.

Conclusion

Farming systems are the backbone of agriculture, serving as the foundation upon which food production, environmental sustainability, and rural livelihoods thrive. These systems encompass diverse practices, techniques, and approaches tailored to specific ecological, climatic, and socio-economic contexts. Their importance in agriculture cannot be overstated. In addition, agricultural systems play a central role in environmental protection and sustainability.

Sustainable farming practices such as crop rotation, agroforestry and integrated pest management help maintain soil fertility, conserve water resources and minimise the use of harmful agrochemicals. By promoting biodiversity and ecological balance, these systems contribute to the long-term health and sustainability of agricultural ecosystems and reduce the adverse environmental effects of agriculture. Moreover, farming systems play a crucial role in ecological conservation and sustainability. Sustainable farming practices, such as crop rotation, agroforestry, and integrated pest management, help preserve soil fertility, protect water resources, and minimise the use of harmful agrochemicals. Promoting biodiversity and ecological balance contributes to agroecosystems' long-term health and resilience, mitigating agriculture's negative environmental impacts.

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EXPLORING EFFECTIVE PROPAGATION TECHNIQUES IN HORTICULTURAL CROPS: CULTIVATING SUCCESS FROM ROOT TO FRUIT

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Introduction

Propagation, the multiplication of plants, encompasses the creation of new plants through various means such as seeds, cuttings, bulbs, and other plant components. It can also denote the natural or artificial dispersal of plants. Another interpretation involves the process of generating multiple plants from a single parent plant or tissue within a specified timeframe. This ancient practice has evolved from traditional field methods to modern in-vitro techniques. Plant propagation is not only economically lucrative but also contributes to employment generation, recreation, and creativity. The success of plant propagation is contingent upon factors like plant species, variety, propagation method, as well as climatic and growth conditions.

There are two type of plant propagation

1. Sexual propagation:

Sexual propagation refers to the method of plant multiplication through seeds, also recognized as seed propagation. This process is commonly observed in various plants such as vegetables, flowers, and certain fruit crops like acid lime, papaya, coconut, phalsa, among others.

Advantages of sexual propagation

Advantages of sexual propagation include its simplicity and cost-effectiveness, as well as the tendency for plants produced through this method to display longevity, extensive root systems, and heightened productivity in contrast to those propagated asexually. Furthermore, sexual reproduction enables the development of hybrids exclusively through seed propagation, and seeds can be stored for prolonged periods, ensuring their viability over the long term.

Disadvantages of sexual propagation

Numerous fruit plants demonstrate heterozygous traits. Plants propagated through sexual means typically entail a lengthier duration before fruit-bearing commences. Seeds of specific fruits, such as Phalsa, Jackfruit, Mango, among others, necessitate immediate sowing post-extraction to preserve viability.

2. Asexual propagation:

Asexual propagation refers to the reproduction of a plant through vegetative components such as buds, stems, roots, leaves, and similar parts.

Advantages of asexual propagation

Maintaining architectural consistency is only achievable through asexual methods. Certain fruit-bearing plants, such as bananas and pineapples, lack viable seeds, necessitating asexual reproduction for multiplication. Vegetatively propagated plants exhibit early fruiting. Control over plant height and the enhancement of resistance to both biotic and abiotic stressors are attainable through the selection of appropriate rootstocks.

Disadvantages of asexual propagation

It does not foster the development of novel varieties. Occasionally, it can be costly and demands specialized techniques. Plants propagated vegetatively may have shorter life-spans.

Methods of asexual propagation

A. Apomictic Seed-

Apomixis refers to a reproductive phenomenon observed in certain plant species where an embryo forms from diploid cells within the seed, independent of fertilization between ovule and pollen. The resulting offspring, termed apomicts, originate through this process.

Seedlings produced through apomixis exhibit genetic uniformity with the mother plant and resemble plants propagated through other vegetative methods, such as citrus and mango, due to sharing identical genetic makeup with the maternal parent.

B. On the own root system-

i. Layering-

Layering is a horticultural technique wherein an adventitious root is generated from a shoot while it remains connected to the parent plant. The external application of auxin has been observed to accelerate root initiation and enhance both the rate and quantity of roots formed per layer. This phenomenon is frequently observed in plants such as guava, litchi, citrus, and others.

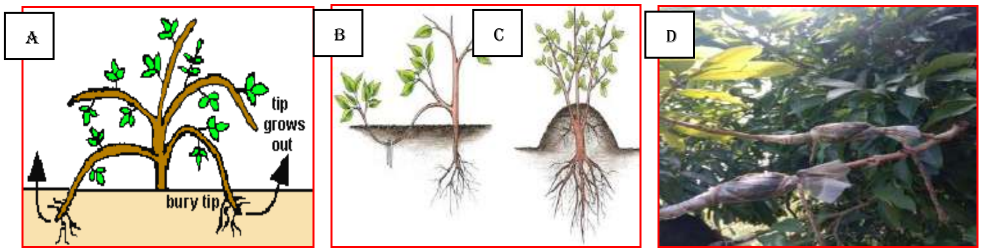

Fig: A-Tip layering, **B-** Simple layering, **C-** Mound layering, **D-** Air layering

Simple- Within a month, rooting occurs in the soil where the tips of the shoot are buried at a depth of 5-10 cm.

Tip- In tip layering, the supple shoots of a plant are gently bent downward towards the ground either during early spring or the rainy season.

Trench- The parent plants are positioned at a 45 degree angle within a trench, with their long and pliable stems anchored to the ground, creating a seamless row of layered vegetation.

Air layering- Typically, shoots that are one to two years old are chosen for air layering. Initially, the leaves are stripped from the lower part of the selected shoots, and then a notch is made or a ring of bark about 2-3 cm wide is removed from the stem. Root-promoting substances can be applied either as a powder, in lanolin, or as a solution. The earth ball should be covered again with sphagnum moss and enclosed with a polythene sheet (for plants like Litchi, lemon, etc).

Mound layering- During the dormant season, the mother plants are pruned back to 5-10 cm above ground level in this technique. Within two months, new sprouts emerge. This method is commonly applied to crops such as apple rootstocks, guava, mango and litchi.

ii. Cutting-

Horticultural crops primarily utilize the following types of cuttings:

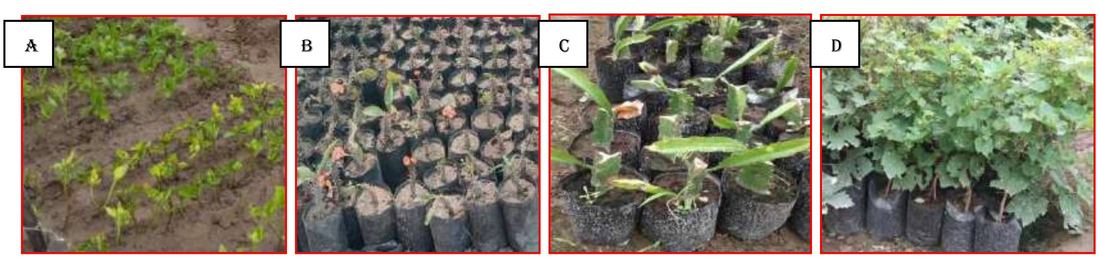

Fig: A- Herbaceou cutting, **B-** Soft wood cutting, **C-** Semi hard wood cutting, **D-** Hardwood cutting

Herbaceous- Herbaceous cuttings are derived from fleshy, non-woody plants such as geraniums, chrysanthemums, coleus, carnations, poinsettias, and various greenhouse crops. Typically, these cuttings measure between 3 to 5 inches in length.

Soft wood- Softwood cuttings refer to cuttings derived from tender, succulent, and non-woody shoots that haven't yet developed lignifications. Typically, their size ranges from 5 to 7.5 cm, although this measurement can vary depending on the species.

Semi hard wood- These specimens are typically cultivated from fresh, young wood of the current growing season and display succulent characteristics. To optimize root development, cutting lengths should range from 7 to 20 cm. These cuttings are crafted by making a straight cut below a node and eliminating some lower leaves. Examples include guava, jackfruit, lemon, and various perennial ornamental plants.

Hard wood- These cuttings are typically gathered during the dormant season, from one year old shoots of the previous year's growth. The length of the cuttings ranges from 10 to 15 cm, with diameters of 0.5 to 2.5 cm. Among the plants suitable for this propagation method are hibiscus, *Rosa sinensis*, pomegranate, kiwi fruit, grape, fig, mulberry, olive, quince, hazelnut, chestnut, plum, gooseberry, apple, as well as numerous ornamental varieties.

C. On the root system of other plant-

i. Budding- Budding, also referred to as bud grafting, is a grafting technique wherein only a single bud along with a portion of bark, sometimes accompanied by wood, is utilized as scion material. The successful fusion of the bud and stock is termed budding.

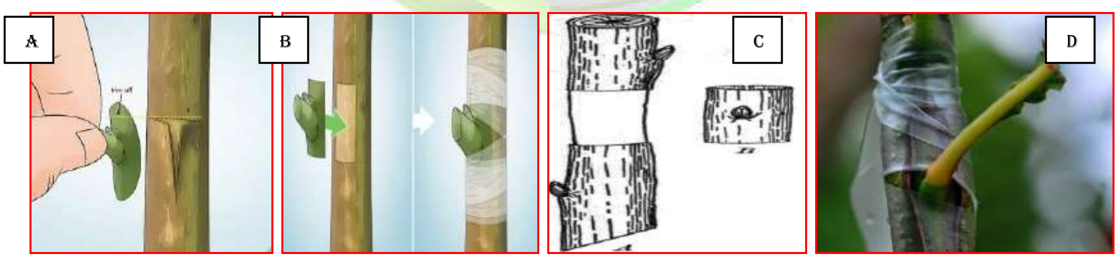

Fig: A- T budding, **B-** Patch budding, **C-** Ring budding, **D-** Chip budding

Methods of budding:

T-budding- Also known as shield budding, involves creating a 'T' shaped incision on the chosen part of the stock using a sharp budding knife. The two flaps of bark are then gently loosened with the budding knife. Buds from the bud wood, selected from a healthy shoot of the current season's growth, are carefully chosen from the middle portion. These buds are removed from the bud wood by making a shallow cut about 5-6 mm below and 2-3 cm above the bud. The shield piece, containing a bud, is then inserted carefully into the 'T' shaped incision on the stock. The bud is firmly pressed in place and secured with a polythene strip.

Patch budding- A rectangular section of bark is entirely removed from the stock and substituted with a similar segment of bark harbouring a bud of the desired variety, such as walnut or pecan.

Ring budding- In the process of in-ring budding, a full circle of bark is excised from the rootstock, effectively girdling it. Simultaneously, a corresponding ring of bark with a bud is removed from the bud stick and carefully inserted onto the rootstock.

Chip budding- A piece of bark and wood is excised from the smooth area between the nodes of the rootstock. Simultaneously, a comparable chip in shape and size is extracted from the desired cultivar's bud wood. Subsequently, a downward incision measuring 2-3 cm is made through the bark and slightly into the wood of the rootstock for grafting purposes.

ii. Grafting-

Grafting involves the skilful fusion of distinct plant parts, enabling them to merge and grow as a unified entity. The segment of the graft intended to form the aboveground portion of the plant is known as the scion, while the portion designated to develop into the root system is referred to as the rootstock.

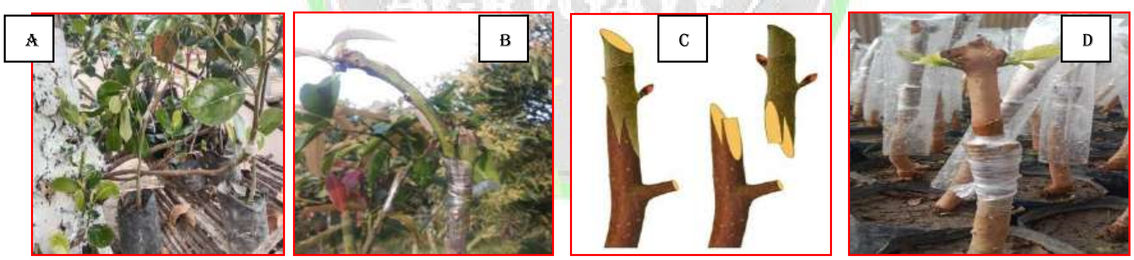

Fig: A- Inarching, **B-** Veneer grafting, **C-** Tounge grafting, **D-** Wedge/Cleft grafting.

a. Attached method of grafting– Inarching resembles approach grafting in that both involve grafting rootstock and scion plants while they remain on their own roots. However, a key distinction lies in the fact that in inarching, the upper portion of the new rootstock plant typically does not surpass the point of graft union, unlike in approach grafting. This technique is employed for replacing damaged roots caused by factors such as cultivation equipment, rodent activity, or diseases. When the damage is significant, seedlings intended for inarching should be spaced approximately 10-15 cm apart around the circumference of the affected tree, as observed in sapota and jackfruit trees, among others.

b. Detached method of grafting

Veneer grafting- A shallow incision, approximately 3 to 5 centimeters in length, is made downward on the chosen rootstock. Near the base of this initial incision, a short inward and downward cut is intersected. Between these two cuts, a small notch is created on the rootstock to remove a piece of wood along with the bark. The scion is prepared with a corresponding long cut on one side and a shorter cut on the opposite side at its base. Insert the scion into the prepared area on the rootstock, ensuring that the cambium layers align on at least one side of the cut surfaces. Securely wrap and tie the scion and rootstock together. Care should be taken to ensure proper alignment and fixation.

Toung grafting- Position the chosen rootstock and scion in proximity to each other. Identify the optimal point of contact for comfortable alignment. Proceed to remove a section of wood, along with a 2.5 to 5-centimeter strip of bark, from both the rootstock and the scion. Next, create a second slanted partial cut, downward on the rootstock and upward on the scion, resulting in thin, tongue-like protrusions of equal size on both stems. Insert the scion into the rootstock so that these tongue cuts interlock securely. Ensure that all manipulated sections are in close contact. Finally, securely tie the manipulated portions together.

Splice or Whip grafting- Return to the rootstock's base and make a slanting cut downwards from the top, measuring 2.5 to 5 cm in length. Repeat this process in reverse on the scion, making a slanting cut upward from the base, also measuring 2.5 to 5 cm. Ensure both cuts are smooth. Join the cut portions of the stock and scion together to form a unified stem. Wrap the union tightly with polythene tape or specialized nursery tape. Remember to remove the tape once the graft has healed; otherwise, growth may be restricted around the union, leading to potential breakage from wind force.

Epicotyle grafting- This technique is frequently employed to quickly propagate mango plants. Copper-colored leaves indicate that the rootstocks, which are 15 days old mango seedlings, are ready. The scion, a 3-4 months old shoot with pencil thickness from the current season's growth, is carefully chosen from the mother plant. It's crucial that the scion possesses 4-5 terminal buds. Prior to grafting, the selected shoot should be defoliated 15 days in advance. This defoliation prompts the buds to swell and encourages early sprouting.

D. Propagation through Specialized Vegetative Structures

Different types of modified plant organs such as bulbs, corms, tubers, rhizomes, etc., serve as storage organs for food and are utilized as planting material. During the conclusion of the season, the above-ground parts of these plants wither away, while the underground portions remain dormant. They reactivate and sprout anew when environmental conditions become conducive.

Fig: Propagation through Vegetative Structures (bulbs, corms, tubers, rhizomes, etc).

a. Separation: Organically, separable structures like bulbs, corms, or cormels are detached and planted individually. Examples include tuberose, tulip, daffodils, onion, garlic (cloves), and gladiolus.

b. Division: The plant's adaptations, including rhizomes, tubers, runners, suckers, crowns, offsets/offshoots, etc., are divided into sections to propagate new plants from each segment. Examples of such plants include alstroemeria, sweet potato, tapioca (cassava), and dahlia.

E. Micro-propagation

Haberlandt, a German plant physiologist in 1902, initially elucidated the biological concept of tissue culture, showcasing the multiplication of plants in both septic conditions and artificial growth mediums from minute plant parts such as meristem tips, callus, embryos, and others.

Merits

Tissue culture enables swift multiplication of genetically identical plants consistently throughout all seasons. Starting from a miniature plant part, tissue culture can generate a whole new plant, unlike traditional methods which often demand a substantial shoot length. Cultivating numerous plants in a confined area through tissue culture ensures homogeneous growth and productivity, contrasting with the extensive nursery space required in conventional methods. Plants propagated via tissue culture are devoid of diseases. Micro-propagation allows for efficient transportation of propagation material over long distances and prolonged storage of clonal material.

Demerits

The expenses associated with establishing and up keeping a laboratory are notably high, potentially outweighing their utility for commonplace horticultural plant applications. Tissue culture techniques demand minimal manpower. Even a minor infection can jeopardize the entire batch of plants. Seedlings nurtured in controlled environments may struggle to thrive when exposed to natural environmental conditions.

Conclusion

Mastering propagation techniques is essential for successful horticultural crop cultivation. Through methods like grafting, layering, and seed propagation, growers can efficiently propagate desirable traits and maintain genetic diversity. Understanding the nuances of each technique empowers farmers to optimize yield, quality, and resilience in their crops, contributing to sustainable agricultural practices and food security.

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STATUS OF PINEAPPLE PRODUCTION IN ASSAM AND STRATEGIES TO INCREASE PRODUCTION

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Introduction

Horticultural crops occupy a unique role in developing countries both in economic and social spheres in respect of improving income and nutritional status particularly of rural masses. The pineapple (Ananas sativus syn. Ananas Comosus Merr) is one of the most important commercial tropical fruits of the world. India ranks 6th in pineapple production in the World, 1,420,400 tonnes (data come from the U.N. Food and Agriculture Organization's(Roy et al, 2013).FAOSTAT database and has been displayed with the permission of FAO). The pineapple belongs to the family of Bromeliaceae (or multiple fruit bearing) plant.Assam produces a large number of fruits, vegetables and spices having high commercial value. Pineapples are one of the largely grown fruit in North Eastern States of India including Assam. Pineapples are very popular amongst consumers and their availability in the form of juice or slices round the year enable the consumers to enjoy them whenever they want.

The local name of pineapple in Assam is 'Anarash' and 'Mati-Kathal'. The different cultivars grown here are Kew, Queen and Mauritius. **Queen variety is widely grown in Assam.** Karbi Anglong, NC Hills and Cachar are the major **pineapple growing districts** of the state. The Kew variety is important for its edible and nutritional components and is grown mainly for canning. The weight of its large fruit varies from 1.5 kg to 3 kg. It is highly juicy with Total Suspended Solids content 8^o to 12^o brix. The colour of the juice is light yellow and has considerable aroma and flavour. This makes it suitable for canning. Bromelin, a proteolytic enzyme in the stem of the pineapple, has various health benefits. It is used to cure lung cancer, allergies, asthma, in anti-ageing treatments and for faster recovery from surgery.Pineapple has recently gained much prominence for its health promoting properties. Fresh pineapple is loaded with many essential vitamins and minerals. Also, fresh pineapple is an excellent source of vitamin C, and the trace element manganese. It is also a good source of vitamin B1, vitamin B6, copper, potassium, magnesium, iron and dietary fibre. It is also a good source of enzyme, bromelain. The fruit is consumed as both fresh and processed forms. A large number of value-added products like, jam, jelly mixed jam, etc. can be produced from it, which will provide remunerative prices to the farming community and will also generate employment for rural people (Das et.al,2016).

Intervention by the technology mission for integrated development of horticulture through an area expansion scheme has triggered the revolution of pineapple cultivation. Pineapple cultivation has drastically improved the economic conditions of the educated unemployed youths and farmers of Assam. Since 1916, welsh Presbyterian evangelist rev. watkin Roberts,who led a band of 15 Hmar families from Tripura to settle in the Hmarkhawlien area of Assam's cacher district, taught the people to cultivate pineapple in this hilltop settlement. The Hmarkhawlien pineapples are reckoned to be the sweetest among all pineapples in India as their sugar content varies between 16 to 28%.

2. Area, Production and Productivity

In Assam, three varieties of pineapple is grown namely Kew, Queen and Mauritius. As per the data available the average productivity of Pineapple in Assam is 18100 kg per ha which means the land is very fertile and adaptable and the fruits are of high of quality having TSS about 12-14, large sized with attractive color and flavor. The data presented in Table No.1 showed a decline of 11 ha area from 2018-2019 under Pineapple production in the state. The decline in the area has not affected the productivity in the state. The productivity has been increase from16.450 t/ha to 18.099 t/ha from 2016 to 2019. The highest area of 3608 ha has been recorded in Dima Hasao district followed by Karbi Anglong district of Assam which gradually increased upto 2018 and then again it has decreased by 137 ha in 2019.The lowest area and productivity has been recorded in Dhubri district of Assam.

3.Cultural practices of pineapple followed in the state

i. **Agro-climatic requirements**

Generally Pineapple is a humid tropical plant and grows well, both in the plains and also at elevations not exceeding 1400 meters in Assam. However, it does not tolerate very high temperature and frost. It starts flowering from March-AprilandJune-July. Sometimes, off-season fruits are harvested from September-December. The optimum temperature required for successful cultivation is 22^0-32^0 C. High temperature at night is deleterious for the growth of the plant and a difference of at least 4^0 C between day and night temperature is desirable. The rainfall requirement ranges between 100-150 cm (Saloni et al 2017).

ii.Soil

The soils of Assam is slightly acidic soil with pH range of 5.0 to 6.0 and is considered to be the best for pineapple cultivation. The soil should be well drained and light in texture. It can grow in sandy, alluvial or laterite soil. However, heavy clay soil should be avoided.

iii.**Propagation**

It can be propagated by sucker,slip and crown.These planting materials of 5-6 months age bear flowers after 12 months of planting except crowns which bear flowers after19-20 months.

iv.Climate

The tropical monsoon climateof Assam is very suitable for Pineapple farming. Heavy rainfall is best for pineapple growth and an optimum rainfall of 1500mm per year is good enough. Temperature range from 8.0 to 36^0 C is good for production of quality fruits and can be successfully taken up till 1500 m above MSL

v.Treatment of planting material

Planting materials should be dipped in Mancozeb-75WP(2g/lit) be fore planting to protect the plants against bud rot.

vi.Time of planting:

The appropriate time of sowing is April to October in Assam condition.

vii.Planting and population:

Planting is done in two-row beds.In each bed,plant at 60 cm from row to row and at 30 cm from plant to plant. Distance between rows of two adjacent beds should be 90 cm. This will accommodate about44,000 plants/ha.

viii. Manure and Fertilizer:

10 to15t/ha of FYM may be applied at last ploughing.N, P_2O_5 and K_2O @ 12g, 2g and 12g, respectively per plant per crop should be applied. Half of N and the whole of $P_2O_5$and K_2O are to be applied as basal dose and rest half of N to be applied as foliar spray.

ix.For foliar applications, 450g urea is dissolved in10 lit of water and sprayed on 200 plants.It will provide1 g of N per plant.Thus forgiving 6g of Nasfoliar application 6 such spraying are required after every 2months.Soil application of 40% of fertilizer of maincrop i.e.4.8gN,0.8g,P_2O_5 and 4.8g,K_2O/plant after harvest of maincrop increase production of ratoon crop of pineapple.

x. Cultural operation

Weeding should be done at least three to four times a year. Hand weeding can be partially eliminated by chemical weedicide.Diuron@3kg/ha as pre-emergence spray can be used economically in the first year to control broad spectrum of weeds in pineapple (50micron) can also be used for controlling weeds. When there is long drought, irrigationmay be given fortnightly.

To protect the fruits from sunburn, partial shade may be provided by planting arhar in between the beds. The spacing has to be adjusted accordingly. Covering the matured fruits with leaves adjacent to the fruits will reduce both sun burn and bird damage.

xi. Crop Cycle:

One main crop followed by two ratoons is practiced in Assam

xii.Flowering

There are two main seasons of flowering-March-April and June-July. Sporadic flowering may take place in other periods also. Fruits usually ripen about 5months after flowering.

xiii. Regulation of flowering and early fruiting

In general, when no special treatment is given, only 50-60% plants flower in main season.With some chemical substances it is possible to get uniform flowering (over 80%) in the main season. For this purpose, Ethrel@100ppm (10ml in 100 lit.of water) solution should be applied to plants one month before flowering. About 30 ml of Ethrel solution should be poured on the core of the plant. Since Ethrel is a costly chemical one tenth of it can be made equally effective (1mlin 100lit) by adding 2% urea and 0.04% sodium carbonate or calcium carbonate.

To delay harvest by a few days (10-15 days) spray the fruit (just 60-70 days ahead of normal harvest) with 300 ppm Planofix.

To ripen the fruit earlier by about 10-15 days spray 500 ppm of Ethrel on the fruit about one month before normal harvest.

xiv.Harvesting

Harvesting is done when the fruits become ye llow in colour. Over ripening on them other plant or any injury to fruits at harvesting should be avoided.For distant market, the fruits may be harvested when they just change colour from green to yellow.

xv.Yield

In Assam condition generally 50-80 t ha^{-1} yield has to be obtained depending upon spacing and cultural practices

xvi. Plant Protection

Generally leaf spot in is a common problem pineapple growing areas.This can be controlled by spraying Mancozeb 75 WP(2g lit^{-1}).

xvii.Benefit: Cost ratio:

The researchers has found main crop B : C ration: 3.70 whereas the Ratooncrop's B ; C ratio is 8.50.

4. Constrains of Pineapple production in the state

The problems faced by the majority of farmers that is lack of knowledge about updated technologies of pineapple cultivation. There is an urgent need for standardization of technology to bring down cost of production of fresh pineapple and its adoption by growers, assured market for the produce and to produce pineapple throughout the year may go a long way in promoting pineapple industry in India. The processing industry for pineapple is limited to a specific location and processing cost of pineapple are high due to high cost of fruit, sugar, containers and overheads and non-availability of fruits throughout the year. Marketing of fresh pineapple is a big problem due to its highly perishable in nature. Mature pineapple fruits cannot be stored for more than 4-5 days after harvesting and any injury to fruits during harvesting and transportation results in poor quality of pineapples and low market demand.

5.Strategy for increasing Pineapple production in the state:

To overcome all these problems emphasis needs to be given for regulation of markets for pineapple and integration of production, marketing and processing activities would help in decreasing marketing cost and thereby encouraging cultivators for self marketing. Formation of

FPO, support from the government, National Horticulture Board, development of infra-structural facilities (transport and communications), improvement in packing, storage and handling facilities, subsidization of inputs are the various aspects which need attention.

6. Constraints/ limitations

There are so many constraints in case of pineapple cultivation like lack of awareness, lack of facility for irrigation, lack of processing centers and storage facilities for which the growers has to sale their products in low prices. There are so many technology gaps like farmer's lethargy / indifference, inadequate / ineffective extension system, inadequate input supply, inadequate credit support and inadequate market infrastructure.Many people have been making effort to take the produce outside the state and even to other countries for a long time. However lack of effective planning and many other factors acted as a deterent towards that objectives.

7. Opportunities

The low input requirement and the remunerative returns have motivated the farmers to adopt more of their horticultural lands under pineapple cultivation. For the development of the socio-economic status of the people and proper utilization of the land which is appropriate for pineapple cultivation, different organization, especially Department of Agriculture Govt. of Assam, National Horticultural Board and the Central Govt. jointly implemented various Agricultural and Horticultural programmes.

'If winter is here, can spring be far behind', an adage, can be aptly termed for the pineapples which are hogging the markets.spoke by DC,Cachar, Assam when first consignment of pineapple went to International market.

Fig.For the first time, a consignment of 15 metric tonnes of pineapples has been exported in a refrigerator truck from Lakhipur in Cachar district to the global market in Dubai.

There is an opportunity to supply pineapple to outside the country as a consignment of 15 metric tonnes of pineapple cultivated in Cachar district's Lakhipur sub-division of Assam,has been exported to the global markets in Dubai , for the first time.The move has been initiated by the Department of Horticulture, Assam and executed through the Agricultural and processed Food Products Authority (APEDA) under the ministry of Commerce and Industry, Govt of India. They have just acting as a catalyst for the 2000 odd farmers of Hmarkhawlien area of Lakhipur where it is extensively cultivated. There is opportunity to organize training for the farmers on grading, processing and various other aspects.

The Cachar Deputy Commissioner Laya Madduri flagged off the maiden export and shared her happiness saying ***"if the effort pays off in the global arena, I hope that the sweet taste of the fruit from Cachar shall bring smiles for all of us."***

The world is moving towards sustainable material for a better life for future generations. The textile industry's main concern is to give mankind superior, sustainable products that are close to nature. Pineapple fibre is one such natural source of minor fibre. It has seen rising demand in the eco market. A detailed study on the source, cultivation, extraction and processing of pineapple fibres reveals that these fibres can be used as an alternative to leather. This edible fruit that has medicinal values now finds another avatar in textile applications. The fibres can be extracted from the leaf as well as the fruit. Textile fibres are obtained from the hair, leaf, bast and fruit of a plant. All vegetable fibres are cellulose-based. Pina fibre is from the leaves of the pineapple plant. Pineapple fibres are sustainable natural materials and demand for pina is increasing in the go-green market as technology progresses in using pina as an alternative to existing textiles and leather.

If new technologies which are feasible, environmentally suitable, economically viable and socially acceptable can be introduced here, there is a fair chance of its success as the farmers are progressive and innovative minded. So, new and low cost technologies must be introduced here through intensive extension system with proper training programmes for farmers from time to time. In this context we have to formulate and implement effective extension programme through which farmers will come to know about the latest package of practices of pineapple cultivations and they can adopt it in their own farmsituations. We have to develop the proper market system so that the farmer can get remunerative price for their crops and they will be interested to increase their cropped area i.e. pineapple. Through the agglomeration of these, the technology that can effectively transfer that will be undoubtedly helpful for the betterment of the farmers and the productivity of pineapple in this region of Assam (Roy et.al,2013)

Conclusion

Pineapple cultivation is highly remunerative and has high potential for value addition and export, but the marketing of raw fruits is done in a nearly imperfect manner (few buyers fixing prices). The price variation is low (CV=8.55%), but pricing system of pineapple is not yet developed. The poor processing facilities restrict the expansion of acreage of this crop. The sector has high potential to generate employment in the rural areas. There is an urgent need to develop infrastructural facilities (transport, communications, storage, etc.), primary markets,cool chain facilities, subsidization of inputs, etc.There is a need to form pineapple growers'marketing co-operatives(Das et al,2016)

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ARTIFICIAL INTELLIGENCE IN MODERN AGRICULTURE

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Introduction

Throughout history, agriculture has served as the cornerstone of human civilization, providing sustenance, and livelihoods, and shaping societies worldwide. However, in the 21st century, agriculture faces unprecedented challenges exacerbated by factors such as population growth, climate change, continuous depletion of productive resources, and the imperative for sustainability, With the global population projected to swell to 9.7 billion by 2050, the demand for food is set to escalate significantly, necessitating a substantial increase in agricultural productivity and efficiency in the agricultural sector to meet the demand of population around world, In this landscape of challenges, artificial intelligence (AI) emerges as a transformative force with the potential to revolutionize agriculture. AI technologies offer innovative solutions to address complex agricultural issues by leveraging data-driven insights, predictive analytics, and automation. Key applications of AI in agriculture include precision farming, crop monitoring, predictive analytics for yield optimization, disease detection, and pest management. These applications empower farmers with real-time information, enabling them to make data-driven decisions, optimize resource allocation, and enhance productivity while minimizing environmental impact, Despite its immense potential, the adoption of AI in agriculture also presents challenges and ethical considerations, These include issues related to data privacy, accessibility of technology, potential displacement of labor, and ensuring equitable distribution of benefits across different farming communities. Additionally, there are concerns about algorithmic bias, the reliability of AI systems in diverse environmental conditions, and the need for transparent governance frameworks to address ethical concerns, In navigating these challenges, stakeholders must collaborate to ensure that AI technologies are deployed responsibly and ethically, with a focus on promoting sustainability, resilience, and inclusivity in agricultural systems. By harnessing the power of AI, agriculture can not only meet the growing demand for food but also mitigate the impacts of climate change, conserve natural resources, and build a more sustainable and resilient food system for future generations.

Role of AI in the future of agriculture, Key applications

1. Precision Farming/Precision agriculture/site-specific resources management

AI enables precision agriculture techniques by analyzing data from sensors, drones, and satellites to optimize inputs such as water, fertilizers, and pesticides, leading to increases in resource efficiency and timely effective utilization of farm resources to agricultural practices to increased efficiency and yield.

2. Crop Monitoring

AI-powered image recognition and analysis can monitor crop health, and growth patterns, and detect anomalies early, allowing for timely interventions and improved crop management to overcome pest and disease issues in the field timely followed operation can enhance the growth and development of the crop plants the fight against the biotic and abiotic issues

3. Yield Prediction

AI models can predict crop yields based on historical data, weather forecasts, and soil conditions, helping farmers optimize harvesting schedules, logistics, and market planning.

4. Disease Detection

AI algorithms can analyze images of crops to identify signs of diseases, pests, or nutrient deficiencies, enabling early detection and targeted treatments to prevent crop losses

5. Weed Management

AI-powered weed detection systems can differentiate between crops and weeds, facilitating precision herbicide application and reducing the need for chemical inputs it reduces the need for more labor requirements and no need to rely on weather factors to follow the cultural operations

6. Robotic Farming

AI-driven robots and autonomous vehicles can perform various tasks such as planting, weeding, irrigation scheduling, nutrient applications, harvesting, and weeding with precision and efficiency, reducing labor costs and human error.

7. Climate Resilience

AI can analyses climate data to predict extreme weather events, optimize irrigation schedules, and suggest crop varieties resilient to changing climate conditions, enhancing agricultural resilience

8. Soil Health Monitoring

AI technologies can assess soil health parameters such as nutrient levels, pH, and moisture content, guiding farmers in soil management practices to maintain fertility and sustainability, instead of applying excessive pesticides to the crop and reducing the cost of cultivation and boost the agricultural productivity

9. Supply Chain Optimization

AI algorithms can optimize supply chain logistics by predicting demand, improving inventory management, and reducing food waste through better distribution and storage practices.

10. Market Analysis

AI-powered analytics can analyses market trends, consumer preferences, and pricing dynamics, enabling farmers to make informed decisions about crop selection, production levels, and marketing strategies to sell at better prices

11. Livestock Management

AI applications can monitor animal health, behavior, and productivity through sensor data analysis, facilitating early disease detection, breeding decisions, and efficient herd management.

12. Water Management

AI-driven irrigation systems can optimize water usage by monitoring soil moisture levels, weather forecasts, and crop water requirements, conserving water resources, and reducing irrigation costs.

13. Pest Control

AI algorithms can predict pest outbreaks based on environmental conditions and historical data, enabling proactive pest management strategies such as pheromone traps or biological controls.

14. Remote Sensing

AI-enabled analysis of satellite imagery can provide valuable insights into land use, vegetation cover, and environmental changes, supporting land management and conservation efforts.

15. Decision Support Systems

AI-powered decision support tools can integrate multiple data sources, expert knowledge, and predictive models to assist farmers in making optimal decisions across various aspects of farm management

Conclusion

Artificial intelligence stands as a transformative force in agriculture, poised to tackle the industry's multifaceted challenges. Through precision agriculture, autonomous farming, and intelligent resource management, AI promises heightened productivity and sustainability. By leveraging AI's capabilities, farmers can optimize inputs, minimize waste, and enhance yields, all while reducing environmental footprints. Moreover, AI-driven insights into supply chains and markets offer farmers valuable intelligence for efficient decision-making and market competitiveness. Yet, alongside these promises lie ethical imperatives and considerations of accessibility. It's paramount to address concerns regarding data privacy, algorithmic bias, and equitable distribution of AI technologies to ensure their benefits reach all stakeholders. As agriculture marches into the future, AI will serve as a cornerstone, securing food security and sustainability for future generations, underlining the necessity of responsible deployment and inclusive access to its potential.

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CULTIVATING PROSPERITY: CELLULAR AGRICULTURE'S TRANSFORMATIVE IMPACT ON BUSINESS OPPORTUNITIES

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Introduction

Cellular agriculture, a cutting-edge field at the intersection of biotechnology and food science, is rapidly gaining traction as a viable and sustainable alternative to traditional farming methods. This article focuses into the myriad ways cellular agriculture presents itself as a lucrative business opportunity. From revolutionizing the meat industry to providing scalable solutions for diverse products, cellular agriculture offers entrepreneurs a chance to not only address environmental concerns but also tap into a burgeoning market driven by conscious consumer choices.

1. The Need for Change: Challenges in Conventional Agriculture

Traditional agriculture faces a myriad of challenges, ranging from resource-intensive practices to environmental degradation. With a growing global population and an increasing demand for protein-rich diets, the strain on agricultural systems is reaching a critical point. The need for a more sustainable and efficient approach to food production has never been more pressing.

2. Understanding Cellular Agriculture: A Paradigm Shift

Cellular agriculture represents a paradigm shift in the way we produce food. Instead of relying on conventional farming methods, which are resource-intensive and environmentally taxing, cellular agriculture leverages biotechnology to cultivate animal and plant products from cell cultures. The process involves growing cells in controlled environments, eliminating the need for vast expanses of land and mitigating the ethical concerns associated with traditional livestock farming.

3. **Revolutionizing the Meat Industry: A Market Ripe for Disruption**

The meat industry, a significant contributor to environmental issues, is a primary focus for cellular agriculture. Lab-grown meat, produced by cultivating animal cells in a controlled setting, offers a sustainable alternative to conventional livestock farming. Entrepreneurs entering this space stand to benefit not only from the environmental advantages but also from tapping into a market increasingly inclined towards ethically produced and eco-friendly meat options.

4. Beyond Meat: Diversifying Cellular Agriculture Products

While lab-grown meat is a headline-grabbing aspect of cellular agriculture, the opportunities extend beyond this single product. Entrepreneurs can explore the production of lab-grown dairy, eggs, and even plant-based products using similar principles. This diversification provides a range of business prospects, catering to varied consumer preferences and dietary choices.

5. Scalability: A Key Driver for Business Success

One of the defining features of cellular agriculture is its scalability. The controlled environment allows for efficient and predictable scaling of operations, ensuring a stable supply chain. This scalability not only addresses concerns related to meeting growing demand but also opens avenues for cost-effectiveness, making cellular agriculture increasingly competitive in the market.

6**. Consumer Trends: The Rise of Conscious Consumerism**

As consumers become more conscious of their environmental impact and health, there is a growing demand for sustainable and ethically produced food products. Cellular agriculture aligns with these evolving consumer preferences, presenting a unique selling point for businesses in this sector. Entrepreneurs have the opportunity to capitalize on this trend and establish themselves as leaders in the emerging market of sustainable food production.

7. Challenges and Opportunities: Navigating the Road Ahead

While the potential for success in cellular agriculture is evident, entrepreneurs must navigate challenges such as regulatory frameworks, public perception, and initial investment costs. Regulatory bodies are still grappling with how to categorize and oversee these novel products, and public perception, though evolving, can be a significant barrier. However, history shows that industries undergoing transformative change often face initial scepticism before widespread acceptance.

8. Investment Landscape: Early Movers and Future Prospects

The cellular agriculture landscape is attracting attention from investors who recognize its long-term potential. Early movers in transformative industries often reap substantial rewards, and cellular agriculture presents a unique opportunity for visionary investors and entrepreneurs to shape the future of food production while reaping the financial benefits of being pioneers in a burgeoning market.

Ten diverse examples of foods that can be produced using cellular agriculture techniques:

1. **Beef:** Cultivated beef is one of the most well-known products of cellular agriculture. Companies can grow beef muscle cells in bioreactors to produce products like burgers, steaks, and ground beef without the need to raise and slaughter livestock.
2. **Chicken:** Cultivated chicken meat involves growing chicken muscle cells in a controlled environment. This can result in products such as chicken breasts, nuggets, and patties that are virtually indistinguishable from conventionally produced chicken.
3. **Fish:** Cultivated fish products are being developed by companies like BlueNalu and Finless Foods. They culture fish cells and encourage them to grow into fillets, fish sticks, and other seafood products, offering sustainable alternatives to overfishing and environmental concerns associated with traditional fishing practices.
4. **Milk:** Companies like Perfect Day are producing cow-free milk by fermenting yeast to produce proteins identical to those found in cow's milk. These proteins are then combined with plant-based ingredients to create milk that can be used in a variety of dairy products like yogurt, cheese, and ice cream.
5. **Eggs:** Cultivated egg proteins can be produced using fermentation techniques. Companies like Clara Foods are developing egg white and yolk proteins that can be used as ingredients in baked goods, pasta, and other food products without the need for hens.
6. **Seafood:** In addition to fish, other seafood products like shrimp and scallops can also be produced using cellular agriculture methods. By culturing the cells of various marine species, companies can create sustainable alternatives to wild-caught seafood.

7. **Cheese:** Cheese can be produced using cellular agriculture by culturing microbial rennet or using recombinant DNA technology to produce cheese enzymes. This allows for the production of cheese without the need for animal-derived rennet.
8. **Gelatin:** Gelatin, a common ingredient in desserts and confectionery products, can be produced using cellular agriculture techniques. By culturing collagen-producing cells, companies can create gelatin that is suitable for vegetarians and vegans.
9. **Honey:** Cellular agriculture can be used to produce honey without bees by engineering yeast to produce honey-like compounds. This lab-grown honey offers an ethical and sustainable alternative to conventional beekeeping practices.
10. **Coffee:** Companies like Atomo Coffee are developing lab-grown coffee using molecular biology and biotechnology techniques. By recreating the flavor compounds found in coffee beans, they aim to produce coffee that is more sustainable and environmentally friendly than conventional coffee production.

These examples showcase the wide range of foods that can be produced using cellular agriculture, offering sustainable, ethical, and environmentally friendly alternatives to conventional animal agriculture. Some international firms involved in cellular agriculture, each contributing to the advancement of this innovative field. Here are a few notable examples:

1) **Memphis Meats (USA):** Memphis Meats is a leading company in the development of cultured meat products. Based in the United States, they focus on producing beef, chicken, and duck meat through cellular agriculture techniques.
2) **Mosa Meat (Netherlands):** Mosa Meat, headquartered in the Netherlands, is known for creating the world's first lab-grown hamburger. They continue to work on improving their technology to scale up production and make cultured meat more accessible.
3) **BlueNalu (USA):** BlueNalu is a company based in the United States that specializes in producing cultured seafood. They aim to address issues such as overfishing, seafood contamination, and supply chain inefficiencies by providing sustainable alternatives to conventional seafood products.
4) **Aleph Farms (Israel):** Aleph Farms, headquartered in Israel, is focused on producing cultivated beef steaks using 3D tissue engineering technology. They aim to offer high-quality meat products without the environmental and ethical concerns associated with traditional animal agriculture.

5) **Perfect Day (USA):** Perfect Day, based in the United States, is a company that produces dairy proteins using microbial fermentation. Their technology allows them to create dairy products like milk and cheese without the need for cows, offering a more sustainable and ethical alternative to conventional dairy farming.
6) **Future Meat Technologies (Israel):** Future Meat Technologies, headquartered in Israel, is working on developing scalable production methods for cultured meat. They aim to make cultured meat production economically viable and environmentally sustainable on a large scale.
7) **Finless Foods (USA):** Finless Foods, based in the United States, focuses on producing cultured seafood products such as fish fillets and shrimp. They use cellular agriculture techniques to grow fish cells in a lab setting, offering a sustainable solution to the depletion of ocean resources.
8) **Shiok Meats (Singapore):** Shiok Meats, headquartered in Singapore, is a cellular agriculture company specializing in cultured seafood, including shrimp and crab. They aim to provide sustainable and cruelty-free alternatives to conventional seafood products.
9) **Cellular Agriculture Ltd. (UK):** Cellular Agriculture Ltd., based in the United Kingdom, is involved in research and development in the field of cellular agriculture. They work on various projects aimed at producing cultured meat and other animal products using innovative biotechnological approaches.
10) **BioFood Systems (Japan):** BioFood Systems, headquartered in Japan, is focused on developing cultured meat and seafood products using advanced biotechnology. They aim to contribute to food security and sustainability by providing alternative protein sources to traditional animal agriculture.

These international firms are at the forefront of the cellular agriculture industry, driving innovation and shaping the future of sustainable food production worldwide. While India is still emerging in the field of cellular agriculture, there are some companies and organizations beginning to explore this innovative technology. Here are a few examples:

1) **Clear Meat (India):** Clear Meat is a cellular agriculture startup based in India. They are focused on developing cultured meat products, including chicken, mutton, and seafood, using tissue engineering techniques. Clear Meat aims to provide sustainable and ethical alternatives to conventional meat production in India.

2) **LabFarm Foods (India):** LabFarm Foods is an Indian company working on producing lab-grown meat and other animal products through cellular agriculture methods. They are developing technologies to culture cells from various sources, including poultry and fish, to create alternative protein sources that are environmentally friendly and cruelty-free.
3) **Orbillion Bio (India/USA):** Orbillion Bio is a biotechnology company with a presence in both India and the USA. While primarily based in the USA, they have collaborations and research partnerships in India. Orbillion Bio focuses on creating cultured meat from exotic and endangered species, aiming to conserve biodiversity while offering sustainable protein alternatives.
4) **Avant Meats (India/Hong Kong):** Avant Meats, although based in Hong Kong, has collaborations and partnerships in India. They specialize in producing cultured seafood, including fish and shellfish, using cellular agriculture techniques. Avant Meats aims to address the environmental and ethical challenges associated with conventional seafood production in India and globally.
5) **Indian Institute of Technology (IIT) Research:** Several research groups within Indian Institutes of Technology (IITs) are also exploring cellular agriculture and tissue engineering for food production. These research efforts contribute to the development of the field within India and may lead to the emergence of more startups and initiatives in the future.

While the cellular agriculture industry is still in its infancy in India compared to other countries, these examples demonstrate the growing interest and potential for the adoption of this technology in the country's food industry. As research and investment in cellular agriculture continue to expand globally, it's likely that India will see more companies and initiatives in this field emerge in the coming years. While there may not be dedicated firms solely focused on cellular agriculture in Maharashtra at present, the state's strong research and industrial base provide a fertile ground for the growth of such initiatives in the future. Additionally, as awareness of the environmental and ethical implications of conventional animal agriculture grows, there may be increased interest and investment in cellular agriculture within Maharashtra and across India.

Conclusion

In conclusion, cellular agriculture is not merely a scientific innovation but a transformative force with immense business potential. As a researcher in this field, the promise of reshaping our approach to food production while capitalizing on the evolving preferences of conscious consumers is both exciting and encouraging. Entrepreneurs who seize the opportunities presented by cellular agriculture stand not only to revolutionize the way we produce and consume food but also to cultivate prosperity in a world hungry for sustainable solutions. The future of business in cellular agriculture is one of growth, innovation, and a positive impact on both the environment and the global food supply chain.

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CASE STUDIES ON FARMING SYSTEM IN COASTAL AREAS

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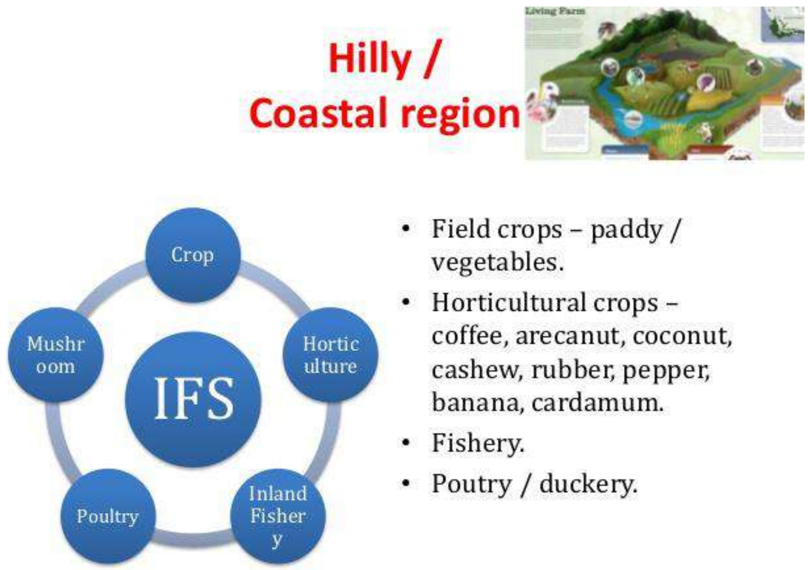
Introduction

The Indian coastal zone has a diversity of geographic and topographical features of mountains, plains, riverine and climatic variations and wide range of cultivated crops and farm animals. The coastal plains and islands have **15 % of the total area of the country**. Coastal region spreads over an area of 11.8 million hectares with a coastline of 8129 km. With an estimated 1.2 million hectares of brackish water area available for the purpose, coastal aquaculture is emerging as a major production activity. Marine fishery supports **two million fishermen living in 2400 fishing villages.** They catch fish with about 1,80,000 artisanal crafts and about 30,000 mechanized boats operating from about 1500 landing centres and 40 major/ minor fishery harbours. Attention is also being paid to culture of finfishes, shrimp, crabs, lobster and seaweeds apart from several non-conventional species (NATP Main Document, 1996). The productivity in the coastal region lag behind significantly from the inland areas due to complex array of constraints involving soil, climate and water related factors. The holistic development of the coastal region can be achieved only through farming system research (Yadav, 2004). Integrated coastal farming system is defined as symbiotic and synergistic integration of viable farm enterprises such as agriculture, livestock and fisheries in the coastal region (CIBA, 2005)

Need for integrated farming system in coastal areas of India

- Coastal areas are most vulnerable to climate change and natural calamities.
- There is plenty of rainfall, which forms the basis for integrated farming system.

- Enterprises which needs less area like mushroom cultivation, dairy, apiary, duckery etc. will increase income and provide livelihood security.
- Integration of livestock over or adjacent to fish ponds helps in easy utilization of wastes of these components.
- As per the convenience of farmer, livestock and fishery may be taken up in separate locations and still can be integrated to cropping systems.

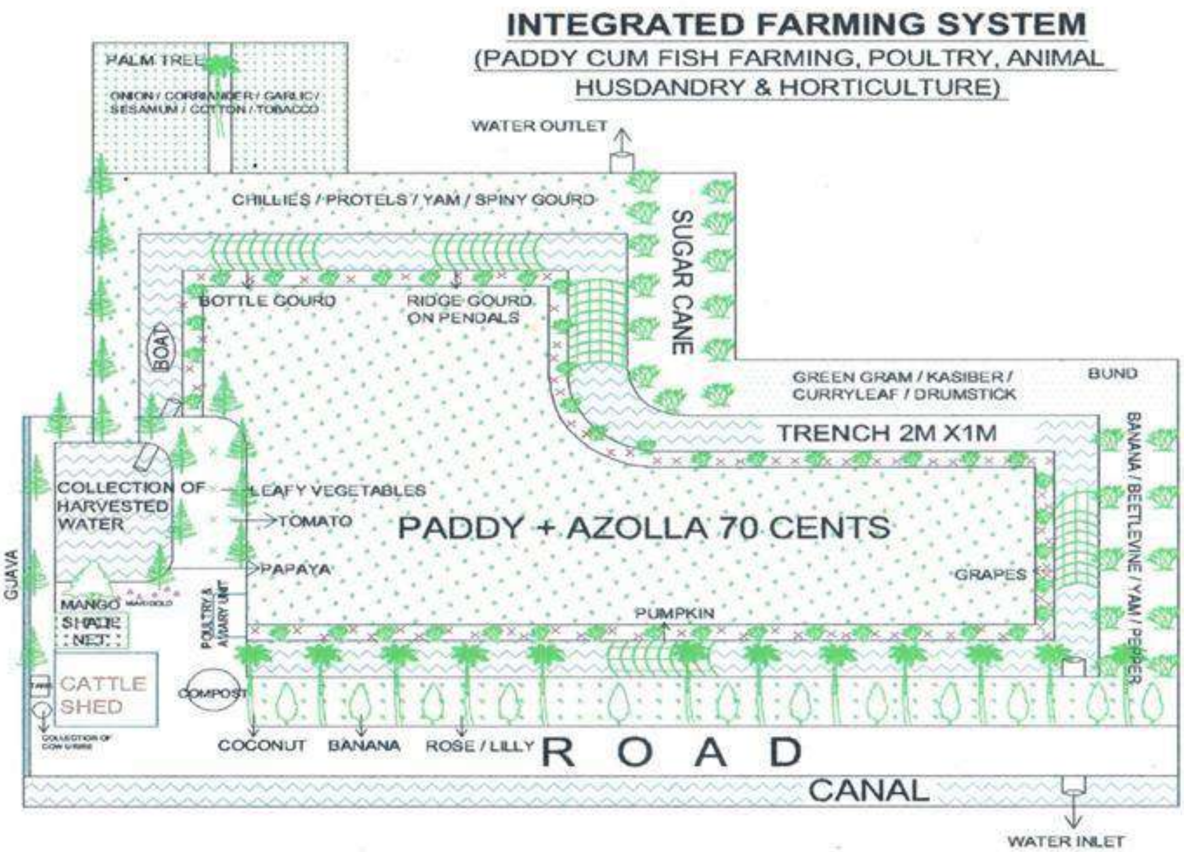


Case Study: 1

An evaluation study on viable integrated farming system (IFS) model in Godavari delta of Andhra Pradesh by Dr. RVSK Reddy *et al.*, 2018

The farmer adopted a low cost IFS model from the year 2010 and the technical team of KVK Venkatarmannagudem evaluated the model by collecting the information through structured interview schedule and observations were recorded in the field. The model farm area is fenced by trees like coconut, banana, and papaya. A trench with dimensions of 2m x 1m having 5 ft depth was dugout around the paddy field. This trench has been used for cultivation of fish and the bunds on the trench were planted with papaya and banana.

About 2500 fingerlings of Catla, Rohu, Mrigal and Grass carp ranging from 100 to 150 g size. were stocked in the trench for the first time. Rice bran and Raw Cattle Dung (RCD) was applied to manure the pond. In between papaya and banana plants, pulses, vegetables like yam, tomato, chillies, onion, leafy vegetables, sesamum, sugarcane were grown to a little extent (5 cents) on the bunds.



Pendals were also erected with bamboo sticks across the trench on the bunds. Cucurbits like bottle gourd, bitter gourd, ridge gourd and teasel gourd were grown and trained onto the pendal. Besides this trench and paddy field, elevated land of about 30 cents is used for growing seasonal vegetables, yam, red gram with high yielding and improved varieties recommended by the Department of Agriculture/Horticulture and KVK.

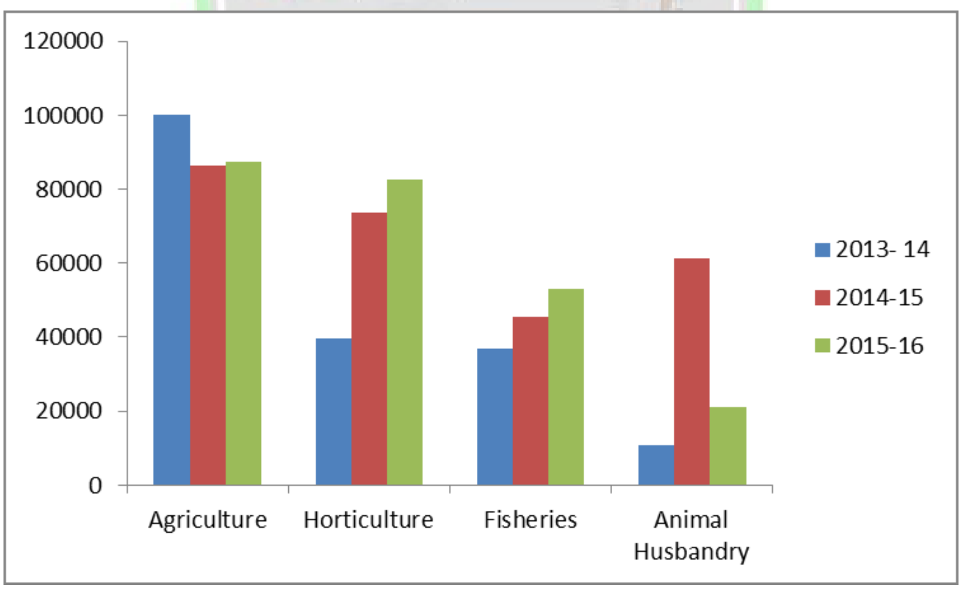
On the other side, the land (10 cents) is divided into five sub components

a) house for livestock with a small pit where cow urine gets collected and recycled
b) two units of organic manure production and azolla
c) poultry and a loft for pigeons
d) small shade net for raising nurseries and

e) small farm pond (10 cents) at the lowest point of the field where the excess water gets harvested.

On the whole, the farm is surrounded by annuals and perennials like marigold, chrysanthemum, rose and lily that act as trap crop as well as add aesthetic value to the field. Paddy is grown in the main field in both the seasons and optimum yields were obtained duly minimizing the cost of cultivation.

Income generation through various sectors



Agriculture stands first and contributes highest income generation followed by horticulture, fisheries and animal husbandry. In the starting years, the income was less, since the plantation of horticulture crops was less and then increased over the next years. Income through fisheries has shown steady increase over the years. The income generation through animal husbandry was high in the year 2014-15, as the poultry and dairy animals yield was high. However, in the next year, the poultry rearing was not done.

Farm Economics for the year 2015 – 16

Crop details	Yield (Kg)	Unit cost (Rs.)	Gross Income (Rs.)	Total Expenditure (Rs.)	Net Profit (Rs.)
Paddy MTU 3626 (Kharif)	2000	20	40000	4100	35900
Paddy RNR 15048 (Rabi)	0	0	0	0	0
sweet corn (Kharif)	2500	10	25000	4850	19650
Intercropping of Onion +Corriander	0/200	0/5	0/1000	1800/150	0/850
Leafy Vegetables	200	5	1000	400	600
Protels (Orissa)	120	30	3600	350	3250
Spiny gourd	90	15	1350	500	850
Cucurbits on Pendals	80	30	2400	450	2050
Banana	45	200	9000	0	9000
Papaya	175	10	1750	150	1600
Coconut	0	0	6000	300	5700
Redgram	20	130	2600	550	2050
Bengal gram	8	60	480	350	130

Gound nut	10	90	900	400	500
Fish reared in trench	550	120	66000	13000	53000
Dairy	26	60	75600	54500	21100

Gross income	**170680**
Total expenditure	**67050**
Net profit	**103630**
Cost benefit ratio	**1-1.55**

In terms of income generation, agricultural crop has dominated followed by horticultural crops, fisheries, dairying and poultry. Since the model depicts a fine blend of all the farm enterprises where in each and every component feeds into the other, thus making efficient utilization of products, by-products and also wastes generated on the farm. Multi cropping as well as farming systems always gives higher returns than mono cropping as such it can be replicated in other parts of the district and across the state based on the feasibility of the water source. In IFS system, the waste generated from one system is utilized as input for the other system.

Case study 2:

1 - ICAR-CCARI, Old Goa-403 402, Goa

Agro-climatic zone - West coast plains and hill region

Project: AICRP on Integrated Farming Systems

<u>Lowland IFS (0.50 ha)</u>

Components and land allocation

- Rice (Jyoti) = 0.40 ha during *kharif*
- Moong (TM 96-2) = 0.1 ha during *rabi*
- Cowpea (Local cowpea) = 0.1 ha during rabi
- Vegetables (Vegetables) = 0.1 ha during rabi

- Commercial crop (Baby corn/sweet corn) = 0.1 ha during rabi
- Bund grown forage crops (Hybrid napier IGFRI- 3, CO-3, CO-4, CO-5) = 0.0315 ha
- Rice cum fish pond= 0.07 ha
- Dairy (cross bred jersy x sindhi) = 24 m^2 for low cost shed
- Kitchen garden : 80 m^2
- Azolla unit

Yield and economics from different crops in lowland IFS

Crop	Yield	Return
Rice	11 quintals	23200
Rice	8 quintals	13200
Cowpea	94 kg	12220
Moong	79 kg	10270
Baby corn	265 kg	13250
Sweet corn	208 cobs	1456
Palak	184 Bundles	1840
Tomato	42 kg	840
Brinjal	310 kg	2480

Radish	280 kg	5590
Red Amaranthus	122 kg	1360
Methi	22 kg	1100
Chili	32 kg	960
Cluster bean	182 kg	3640
Total		91406

Poultry (12 Birds)

Poultry		
Eggs	270 no.	1890
Total		1890

Dairy

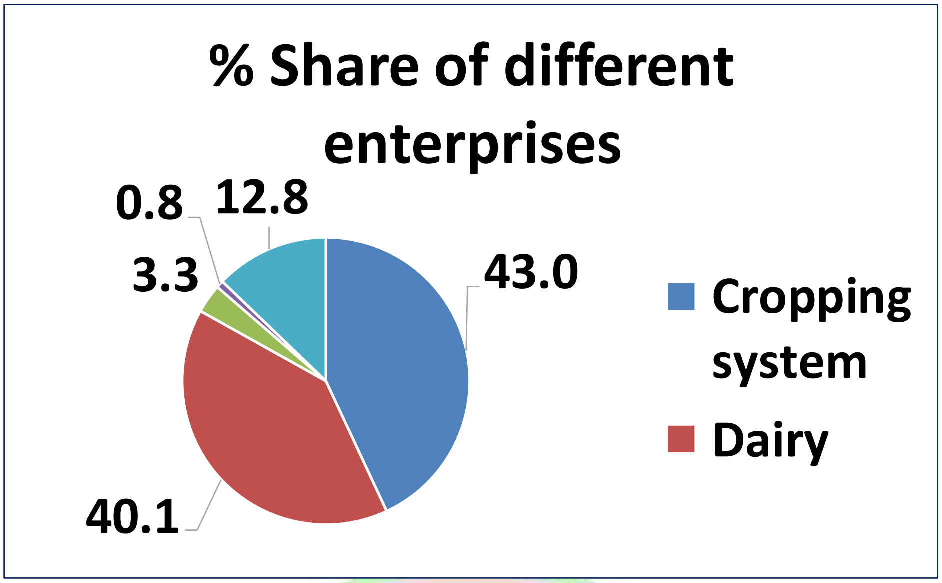
Dairy	Yield	Gross Return	Cost of production	Net return	Employment
2 cows	2700 lit.	108000	45800	62200	80

Kitchen garden and boundary plantation

Banana	185 kg	4625
Methi	6 kg	300
Palak	11 kg	220
Radish	22 kg	660
Red Amaranth	16 kg	320
Total		5905

Economics of lowland integrated farming system

Components	Gross return	Cost of cultivation	Net return	Employment
Cropping system	91406	24549	66857	125
Dairy	108000	45800	62200	80
Kitchen garden	5905	850	5055	5
Poultry	1890	600	1290	5
Fishery	22400	2500	19900	5
Total	**229601**	**74299**	**155302**	**220**



On station farming systems developed in various regions of India, their productivity and profitability

NARP zone (location of Zone)	Farming system	Area	Mean production(Equivalent yield of base crop of region) (t)	Mean net returns (Rs)
Bhubneswar (Odisha)	Cropping systems (0.32 ha) + horticulture (0.19ha)+Dairy (2 cows)+fishery (0.33 ha)+Poultry (380 nos.) + Duck (20 nos.)+ agroforestry (0.094 ha)+ Vermicomposting (0.0033ha) + mushroom (0.010 ha)+biogas (0.0048 ha)+apiary (2 boxes)	1.25	22.8	75129
Thanjavur (TN)	Cropping systems (0.61 ha)+horticulture (0.10ha) + Dairy (1 cow +1 buffalo) + fishery	0.80	15.0	138325

	(0.08ha) + Poultry (150 nos) + Vermicompost (0.002 ha)			
Karjat (Maharashtra)	Cropping systems (0.50 ha)+horticulture (0.40ha)+dairy (3 cows)+Poultry (90 nos)+ goat (6 nos)+ vermicomposting (0.0018ha)	1.00	23.6	99000
Goa (Goa)	Plantation crops (Cashew, coconut, arecanut with intercrops)(0.70ha)+ Piggery+Poultry+seedling Production unit	0.79	24.0	86756
Karmana (Kerala)	Cropping systems (0.20 ha))+dairy (1cows+I buffalo)+ duck(150 nos)+ fishery (0.02ha)+ vermicomposting (0.0004ha)	0.20	8.2	60555

Case study 3

Broad Bed and Furrow (BBF) based farming system involving rice + vegetable + fodder + fish for coastal waterlogged areas by Ravisankar et al., 2010

- Raised and Sunken Bed (RSB) system can serve as climate resilient practice in the rice based farming systems especially in the coastal areas where in inundation of rice fields are expected due to the sea level rise.
- It is a technique of land manipulation to grow vegetables, fish and fodder together right in the midst of rice fields.
- The system is found to increases cropping intensity from the present level of 100% in the rice to 300% in the beds and 200% in the furrows of the BBF system besides, reducing the salinity problem in degraded land & water.
- Net return of Rs. 1.2 lakhs/year can be obtained from one ha area.

Case Study 4:

MULTI ENTERPRISE FARM POND BASED SYSTEM FOR COASTAL DEGRADED LANDS by Ambast *et al.*, 2011

- Harvesting of rainfall and surface runoff from surrounding areas are the major objectives of farm pond with the aim of recycling the water for crops, animals during dry season.
- In the process, multi enterprise farm pond based production system can be developed to ensure multiple uses of water and income from components.
- Due to the factors of soil salinity and back waters in coastal areas especially in the forthcoming scenario of climate change having the influence of sea level rise, the farm ponds in coastal/degraded lands are expected to have either fresh or brackish water.
- In brackish water based farming system, apart from saline tolerant lines of rice up to an extend of 6 dS/m of electrical conductivity, ducks can serve as an important component as no mortality was observed when introduced gradually to saline water of different concentrations up to 15 ppt.
- The body weight recorded at different week intervals do not pronounce much difference in different concentration of salinity for a period of one, two and three week's interval.
- Additional return of Rs 4000/- from 600 m^2 pond can be obtained from the duck component within four months through sale of eggs for ensuring rotational livelihood of farmers especially in the disadvantaged areas having coastal salinity as a constraint. Saline tolerant fodders can also be grown on the bunds of farm pond to support livestock production (cattle & goat).
- Brackish water prawn can be reared in the ponds.
- After testing the water quality in the pond, water can be utilized for irrigation during dry period.

Case study 5:

Income and employment generation under IFS in Coastal area of Kalahandi district of Orissa by Nanda *et al.*, 2007

Income and employment generation under IFS

Location: Kalahandi district of Orissa

Enterprises	Unit	Cost of production (Rs./unit)	Gross return (Rs./unit)	Net return (Rs./unit)	B:C ratio	Man days
Crop component	5.0 ha	2,28,000	6,82,900	4,54,900	3.00	1310
Animals (2 cows + 3 buffalo)	5 Nos.	16,200	38,880	22,680 (4.6%)	2.40	140
Poultry (40 chicks + 40 ducks)	80 Nos.	2,000	11,600	9,600 (1.9%)	5.80	60
Pisciculture	0.2 ha (fingerlings)	8,000	20,000	12,020 (2.4%)	2.50	45
Total	**5.2 ha**	**2,54,200**	**7,53,380**	**4,99,180**	**2.96**	**1,555**
Conventional systems	**1.4 ha**	**13,100**	**19,220**	**6,120**	**1.40**	------

On- farm experiment conducted in the farm of Mr. Murli Budhia, Vill. Kanakpur, Bhawanipatna 29

(Nanda *et al.*, 2007)

Result:

He concluded that the gross production, net production and B: C ratio was highest with the adopted IFS when compared to the conventional system of farming. Among the components of IFS the highest return were obtained by the crop component followed by livestock component.

Case study 6:

Impacts of Shrimp Farming on the Socioeconomic and Environmental Conditions in the Coastal Regions of Bangladesh by Islam *et al* ., 2003

- Shrimp culture has been developed extensively in the coastal areas for more than a decade due to abundant natural fry and brackish water in the estuaries of Bay of Bengal.
- At present, there are **15,978** large and small size **shrimp farms consisting of 147,000 ha** of land in Bangladesh.
- The study was carried out to analyze the comparative economic returns of alternate shrimp-crop farming and to assess the socioeconomic and environmental impacts of shrimp farming in coastal areas of Bangladesh.

- Ninety shrimp-crop farmers and 30 rice farmers were selected to determine and compare the economic returns of alternate shrimp-crop farming.

a) Alternate shrimp-rice farming: In Khulna region - one crop aman rice (e.g. local varieties and HYV) is grown between August/September to December, which is followed by crop of shrimp in between February to July/August.

b) Alternate shrimp-salt farming: Seawater is allowed to enter the salt beds surrounded by low earthen dikes and preserved and evaporated during the dry months between December to mid April. Salt can not be produced between May and early November due to rainfall. Under this system shrimp is cultured through May to October.

c) Year round shrimp farming: Shrimps are cultured in the farm for the period of 8-9 months starting from April or November. Partial harvest and partial stock is done within this period. For rest of the period farmers use to rear shrimp post-larvae (PL) in the canal or ditch of the shrimp farm and these PL are used for the next production season.

d) Year round rice farming: Within the vicinity of shrimp growing areas, still some areas are kept away from shrimp farming where farmers produce different crops specially rice. Farmers prefer rice cultivation to shrimp farming and they protect their land from intrusion or flooding saline water.

Cost and returns	Alternate shrimp-rice farming	Alternate shrimp-salt farming	Year round shrimp farming	Year round rice farming
Gross income				
i) Shrimp + fin fish	96,775 (90)	114,925 (46)	125,005	-
ii) Rice	10,460 (10)	-	-	44760
iii) Salt	-	132,240 (54)	-	-
A. Total gross income (TGI)	107,235	247,165	125,005	44,760
Total cost				
i) Shrimp	39,719	69,091	47,779	-
ii) Rice	5,216	-	-	15,062

iii) Salt	-	23,026	-	-
Total cost (TC)	44,935	92117	47,779	15,062
Variable cost				
i) Shrimp	23,254	35,341	32,277	-
ii) Rice	5,216	-	-	15,062
iii) Salt	-	23,026	-	-
Total variable cost (TVC)	28,470	58,367	32,277	15,062
Cost and returns	Alternate shrimp-rice farming	Alternate shrimp-salt farming	Year round shrimp farming	Year round rice farming
Fixed cost				
i) Shrimp	16,465	33,750	15,502	-
ii) Rice	-	-	-	-
iii) Salt	-	-	-	-
Total fixed cost (TFC)	16,465	33,750	15,502	-
B. Net return				
i) Shrimp	57,056	45,834	77,226	-
ii) Rice	5,244	-	-	29,698
iii) Salt	-	109,214	-	-
C. Total net return				
TNR = TGI – TC	62,300	155,048	77,226	29,698

The total gross and net returns were highest with Alternate shrimp-salt farming followed by Year round shrimp farming. The results obtained indicated that shrimp farmers and other related people acured socio economic benefits from shrimp culture.

Case Study: 7

IFS in cyclone affected coastal Odisha

- IFS around sub surface water harvesting structure was implemented in participatory basis for 22 locations in coastal waterlogged ecosystem devastated by 1999 super cyclone where saline aquifer exists beyond 3-7 m below ground level, and fresh water aquifer floats over it.

- This fresh water was harvested by constructing sub surface water harvesting structures up to a depth of 3 m and the stored water was utilized for aquaculture and irrigation of the crops grown on the bund and in surrounding area.
- Introduction of integrated farming system approach (aquaculture, water chest nut, on dyke horticulture and vegetables in the pond command area) in those structures resulted in gross water productivity of Rs. 12.93 to Rs. 47.20 per m 3 of water used.
- The impact of this technology resulted in construction of 135 such new structures (SSWHS) by farmers in the coastal tract of Erasama.
- Consequently, significant increase in crop production (3-4 fold), water productivity (Rs. 12.93-Rs. 47.20 per m3) and cropping intensity (103-230%) has led to the socio-economic up liftment of the resource-poor farmers with diversified livelihood options.
- The findings can be replicable in different waterlogged eco-systems of India

Case Study 8:

Integrated farming system in Mahanadi delta (Odisha State) by Jayanthi *et al.*, 2001

- A unit was developed in Khentalo village of Barmania Pat (waterlogged area) where water logging was up to 2 m depth.
- Out of 2.47 ha waterlogged area of the farmer, 1.64 ha was converted into grow-out pond for fish and prawn culture while vegetable, flower and fruits were grown on 0.83 ha of raised embankment all around the pond since 1989.
- Poultry sheds were also constructed for rearing 4000 birds in such a way that their droppings could fall into pond as organic manure and feed for fish.
- Gross and net returns from fish and prawn culture alone during 2002 were Rs. 6, 17,160 (Rs. 3, 76,317 per ha) and Rs. 3, 31,065 (Rs. 2, 01,868 per ha) respectively.

- The farmer initially invested Rs. 1,23,910 in 1988 towards construction of the pond plus infrastructure and earned a net return of Rs. 40,554 per ha of whole system in 1989, which gradually increased up to Rs. 1,32,894 per ha in 1997

Case Study 9:

Economic analysis of integrated farming systems in the Kuttanad region of Kerala state, India: A case study by Aiswarya Sabu *et al.*, 2016

Farming system	**Farming System**	**Total Cost**	**Gross Returns**	**Net Returns**	B:C ratio
FS I	Rice + Duckery	1010188.88	1549052.14	538863.26	1.53
FS II	Rice + Fishery	11355.81	293081.37	181725.58	2.63
FS III	Coconut+ Banana + Poultry**	503334.66	1147197.9	643862.63	2.27
FS IV	Coconut+ Banana + Cow***	134284.6	292508.6	158223.9	2.17
FS V	Coconut + Poultry + Cow	744352.93	927947.67	183594.57	1.24
FS VI	Coconut+ Banana + Goat	163809.14	248325	184515.9	1.51
FS VII	Coconut+ Banana + Poultry + Cow	639200.91	1473329.1	834128.19	2.30
FS VIII	Coconut+ Banana + Poultry + Goat	645593	1361198	714497.3	2.10
FS IX	Coconut+ Banana + Poultry + Goat + Cow	892821.76	2557325.33	1964503.57	2.86
	Standard Deviation	335315.4	757719.1	575716.5	0.54

Result

The study revealed that rice + fish and Coconut + Banana+ Dairy cow + Poultry+ Goat were the most profitable farming systems with a benefit cost ratio of 2.63 and 2.86 respectively. Coconut + Poultry + Cow (FS V) and Coconut + Banana + Goat (FS VI) systems appeared to be the least profitable systems relatively with a benefit-cost ratio of 1.24 and 1.51 respectively.

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Volume: 04 Issue No: 04

LISTENING TO PLANTS: THE PROMISE OF PLANT ACOUSTIC FREQUENCY TECHNOLOGY

Article ID: AG-VO4-I04-40

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Introduction

In the fast-paced world of technology, a new frontier is appearing – soundwave agriculture. The world around us is full of sounds and vibrations. Even though we might not notice them, plants can sense these vibrations well because they've adapted to be very sensitive to them. Understanding how plants communicate through sound isn't just interesting for scientists. It has huge benefits for farmers and environmentalists too. By listening to the sounds plants make, farmers can improve how they grow crops, protect them from pests and diseases, and make their farms more resilient. Also, studying plant sounds helps us understand ecosystems better and how to protect biodiversity. Recent studies indicate that acoustic waves can have an effect on plant health, and help plants adapt to adverse environments (Mishra and Bae, 2019). As we explore this new field, there are endless possibilities. We could learn to understand the language of plants and use their sounds to solve real-world problems. It aids in overcoming the rooted lifestyle of the plants.

Understanding acoustic waves

Sound is created when something vibrates and makes the air around it vibrate too. These vibrating air molecules create a wave of pressure that travels through the air until it reaches our ears. When the wave reaches our eardrums, we hear it as sound. So basically, sound is just the movement of vibrating air molecules that our ears can detect.

The decibel, measured on a logarithmic scale, quantifies sound intensity. When sound sources overlap, their combined volume doesn't merely add up linearly. For example, two 50 dB sounds together yield only about 53 dB. It can be calculated by the below Sound Pressure Level (SPL) formula. Sound necessitates a medium for transmission and cannot travel through a vacuum (Mohanta, 2018).

$$\textbf{SPL}_{\textbf{(Total)}} = \textbf{10 log}_{\textbf{10}} \sum_{i=1}^{n} 10^{SPLi/10}$$

The sensitivity of plants has evolved to a level that besides responding to the key physical stimuli of 'light' and 'temperature' they can even perceive mechanical stimuli such as touch, wind, rain, etc. "*The Secret Life of Plants*" by Peter Tompkins and Christopher Bird popularized the idea. The book showed how sound affects plant growth, both positively and negatively, according to leading scientists of the time. Physicist and musician Joel Sternheimer used sound to create music that helps plants grow better by making them produce more proteins. He has sought international patent protection for this innovative concept (RexResearch, n.d.)

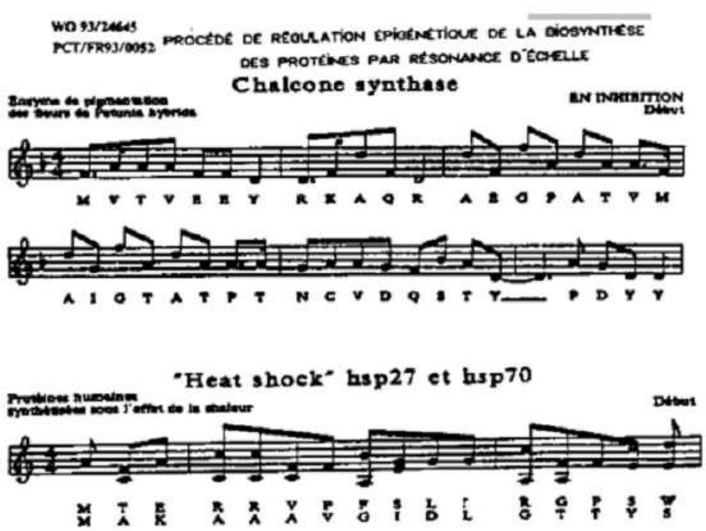


Fig. 2. John Sternheimer Patents (RexResearch, n.d,)

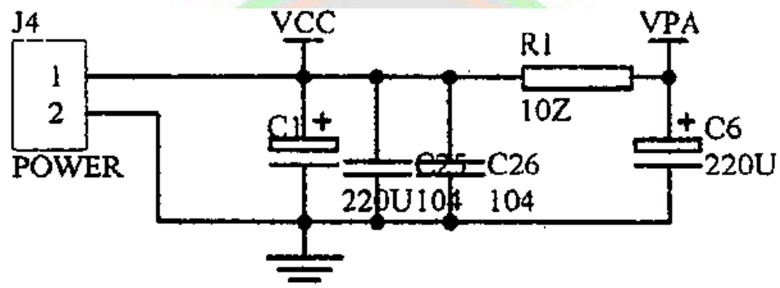
Plant Acoustic Frequency Technology

Plant acoustic frequency technology (PAFT) is a new agricultural production technology that can increase crop yields through sound wave technologies (Mishra *et al.*, 2016).

The working principle of PAFT is to apply a specific frequency sound wave matched with the frequency of crop self-sound, to generate resonance, improve the electron flow rate in plant cells, enhance photosynthesis and respiration, and promote the absorption and transformation of elements by plants (Hassanien *et al.*, 2014)

The first patented PAFT includes,

- ✓ Plant Acoustic Frequency Generator: Microcomputer-based device with an acoustic frequency generating unit.
- ✓ Controlled by Single-Chip Microcomputer: Offers flexible programming for different acoustic signals and modes.
- ✓ Compact, Efficient, and Low Power: Provides stable performance with practical value for plant growth stimulation.



QINGDAO GAOXIN PHYSICAL AGRICULTURE SCIENCE TECHNOLOGY Co. Ltd.

(Jun *et al*., 2010)

The placement of the source of the frequency generator is also related to the sound pressure level (SPL). The SPL decreases in direct proportion to the reciprocal of the distance (1/r) from the source of the sound. This may be given as,

$$I = P/A = P/(4\pi r^2)$$

The relationships between intensity (I), power (P), and area (A) imply that as the area increases, the intensity decreases since intensity is inversely proportional to area.

Applications in Agriculture

The utilization of ultrasonic sound waves represents a sophisticated method for enhancing seed quality and promoting seed germination, growth, and enzyme activity while conserving water and energy. Studies have shown that ultrasonic treatment modifies the seed coat harmlessly for natural drying and storage, with optimal effects observed within specific time frames. Additionally, soundwave exposure has been found to influence various aspects of plant growth and development, including root initiation, bulb generation, and flavonoid synthesis, mediated by alterations in gene expression. Recent research indicates that sound exposure can enhance plant immunity and trigger defense mechanisms against pathogens, potentially offering a novel approach to crop protection. Furthermore, there is emerging evidence suggesting that plants may utilize sound signals, particularly during drought conditions, to communicate with neighboring plants and optimize their response to environmental stressors. These findings underscore the diverse applications of soundwaves in agriculture, presenting promising avenues for crop management and yield enhancement.

Scientists from Tel Aviv University, MIT, and Harvard found that plants under stress emit ultrasonic clicks beyond human hearing capability, caused by conditions like drought, infections, or injuries. Ultrasonic microphones recorded these sounds, and machine learning techniques were employed to differentiate between stressed and healthy plants. The ultrasonic clicks emitted by stressed plants range between 40 and 80 kilohertz.

Sound frequencies ranging from 40 to 104 dB applied for 3 hours daily on various plant materials, including wheat, strawberry, cowpea, eggplant, mushroom, and muskmelon, resulted in increased growth, yield, root activity, and flower production (Hassanien *et al*., 2014).

Conclusion

In summary, plant acoustic frequency technology (PAFT) presents exciting progress in agriculture, harnessing sound waves to improve crop yields, seed germination, and plant immunity. Ultrasonic sound waves offer a refined approach to enhance seed quality and influence diverse aspects of plant growth and development. Moreover, the emission of ultrasonic clicks by plants in response to stressors underscores their adaptability and communication abilities. As we delve further into understanding plant acoustics and utilize sound in plant biology, we pave the way for a greener, more resilient, and inclusive future of farming.

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SAVING YOUR BRINJAL HARVEST: HOW TO IDENTIFY AND CONTROL LITTLE LEAF DISEASE

Article ID: AG-VO4-I04-41

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Introduction

The little leaf of brinjal, known as little leaf disease or phytoplasma yellows, is one of the most serious diseases affecting brinjal (eggplant) cultivation. It's caused by phytoplasma, a parasitic microorganism in the plant's phloem tissues. This disease can cause significant economic losses reaching up to 100% in epidemics for brinjal growers, particularly in India where it's widespread. The disease occurs in almost all the states of India. This graft-transmissible disease was first reported in Coimbatore (Thomas and Krishnaswami, 1939). There is hardly any variety of brinjal which is resistant to this disease. Hence, it is essential to be aware of the identification of disease, cause, etiology, spread and epidemiological condition for effective management of this devastating disease.

How to identify the little leaf disease?

The most prominent symptom of little leaf disease is, as the name suggests, the development of abnormally small leaves. The leaves become stunted and malformed, often appearing chlorotic (yellowish) and taking on a leathery texture. Additionally, the petioles, the stalks connecting the leaves to the stem, become shortened, making the leaves appear clustered around the stem. Phytoplasma infection displays a wide variety of symptoms in plants and these symptoms may influenced by different factors like host, plant age, infection time, virulence of strain, disease stage, time since infection and environmental factors like light and temperature.

- **Stunted growth:** Infected brinjal plants exhibit stunted growth, remaining considerably shorter than healthy plants.

- **Smaller leaves:** The most characteristic symptom is the production of significantly smaller leaves compared to healthy plants.
- **Yellowing leaves:** The leaves often develop a yellowish discoloration due to chlorophyll deficiency.
- **Leathery leaves:** The affected leaves become tough and leathery to the touch.
- **Shortened petioles:** The petioles, the stalks connecting the leaves to the stem, become shortened significantly. This makes the leaves appear clustered around the stem.
- **Increased branching:** The brinjal plant produces an excessive number of branches, often appearing bushy.
- **Deformed flowers and fruits:** In severe cases, flowers become malformed and fail to develop into fruits. If fruits do form, they may be small, hard and inedible.

What causes little leaf disease in brinjal?

The little leaf disease is caused by phytoplasma, a microscopic, cell-wall-less parasite that resides in the phloem tissues of the brinjal plant. Phytoplasma etiology of little leaf disease of brinjal in India has been confirmed based on characteristic symptomology, visualization of the phytoplasma through electron microscopy and verification using PCR assays..

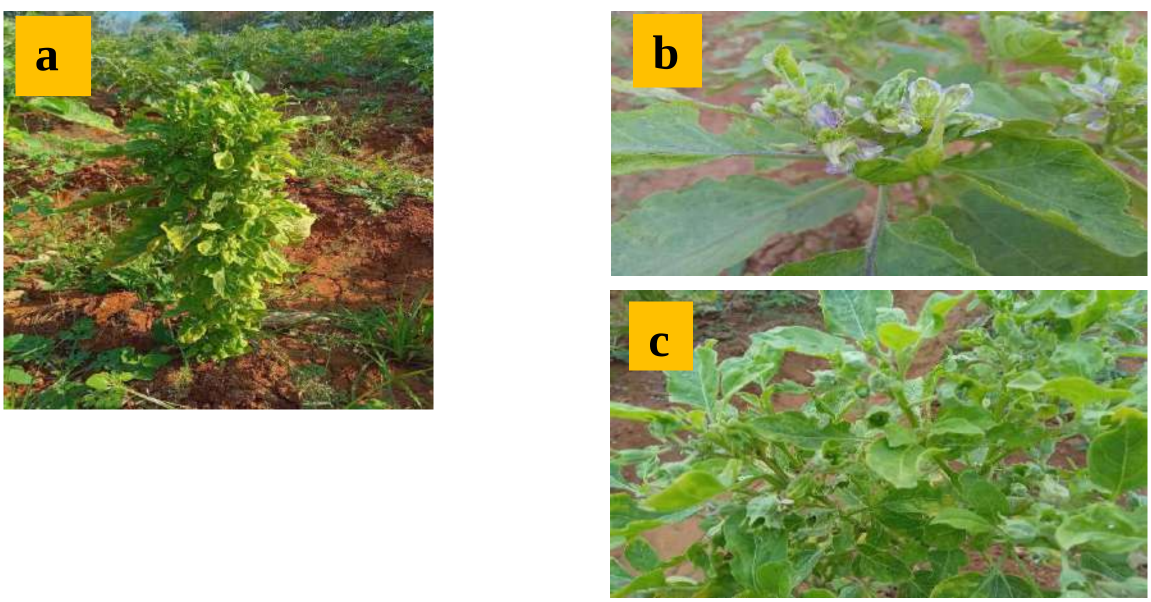

Fig. 1. Typical symptoms of little leaf disease observed in an organic field condition at KRISAT. a) Plant displaying stunted growth, bunchy appearance with shortened internodes. b) Modification of flowers into a leafy-like structure. c) Mixed infection of Phytoplasma with virus.

Studies have identified five ribosomal subgroups (16SrI, 16SrII, 16SrVI, 16SrIX and 16SrXII) of phytoplasma associated with the disease across various geographical locations. Notably, India harbors phytoplasma strains belonging to 16SrI, 16SrII and 16SrVI. Moreover, mixed infection in brinjal by phytoplasmas belonging to the 16SrVI group along with begomoviruses was reported in Meerut, India (Singh et al., 2015). Mixed infections of *Potato virus X*, *Potato virus Y* and little leaf phytoplasmas were also reported in brinjal plants showing little leaf and mosaic mottling disease in India (Kumar et al., 2016). The occurrence of mixed infection may enhance disease severity and yield loss when compared to those of a single infection

How is it getting transmitted?

Insect vectors play a key role in the transmission of this phytoplasma disease. Phytoplasmas are transmitted from infected plants to healthy ones by brown leafhoppers, small, sap-sucking insects. *Cestius* (*Hishimonus*) *phycitis* is the primary leafhopper vectors responsible for transmitting the little leaf disease in brinjal. Grafting and dodder transmission also help to transfer phytoplasmas from infected to healthy plants. Moreover, several weed species are reported to be an alternate host for phytoplasmas. For instance, prominent weeds identified as potential reservoir hosts are *Datura stramonium*, *Cannabis sativa*, *Portulaca oleracea* and *P. grandiflora* for brinjal little leaf phytoplasma (16SrVI) in the Asian and European continents.

Fig. 2. The little leaf disease's insect vector of brown leaf hopper (*Cestius phycitis*) (Sivalingaswamy et al., 2022)

How to manage little leaf disease in brinjal?

Unfortunately, there is no known effective control measure for brinjal plants already infected with little leaf disease. However, several management practices can help prevent the spread of the disease and minimize its impact on brinjal cultivation.

- **Roguing and destruction:** Regularly inspect brinjal fields and remove and destroy any plants showing symptoms of little leaf disease. This helps prevent the spread of the disease to healthy plants.
- **Crop rotation:** Practice crop rotation with non-susceptible crops to disrupt the life cycle of the phytoplasma and leafhoppers.
- **Planting resistant varieties:** Planting brinjal varieties resistant to little leaf disease can significantly reduce disease incidence. Some of the resistant and moderately resistant varieties available Pusa Purple Cluster, Pusa Purple Long, Arka Sheel, Aushy, Manjari Gota and Banaras Giant.
- **Weed control:** Manage weeds in and around brinjal fields, as some weeds can serve as alternative hosts for phytoplasmas and leafhoppers.
- **Antibiotic treatment:** In some cases, treatment with tetracycline antibiotics @ 10-50 ppm at 15 days intervals may prove beneficial in controlling the phytoplasma. However, this approach requires consultation with an agricultural specialist.
- **Botanicals application:** Apply Azadirachtin @ 10,000 ppm, an antifeedant and insect repellent to manage the insect vector.
- **Insecticide application:** Apply insecticides before transplantation, dip the seedlings in 0.2% carbofuran 50 STD solution and spray with dimethoate 0.3% to control leafhopper populations, the primary vectors of the little leaf disease (Not applicable to organic fields).

Conclusion

Disease identification and management is a crucial part of agriculture for successful crop cultivation. Timely identification and application of management practices make plants escape from the potential threats of pests and disease. By implementing the aforementioned management practices, brinjal growers can effectively minimize the impact of little leaf disease and ensure a healthy and productive brinjal crop.

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POSTHARVEST DISEASE MANAGEMENT OF TOMATO

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Introduction

Tomato is the world's second most crucial vegetable crop next to potato, has high nutritional value, and has become an integral part of everybody's daily diet. At the same time, during cultivation and storage, this crop is susceptible to several microbial pathogens and leads to more than 200 diseases caused by fungal, bacterial, or viral pathogens.

Fungal diseases

Postharvest disease, which affects the crop after harvest, leads to a significant loss and rises during the last 10 years. Some of the important fungal diseases which directly affect the tomato fruits are mentioned in Table, along with the characteristics of the concerned pathogen and the important management strategies.

Bacterial diseases

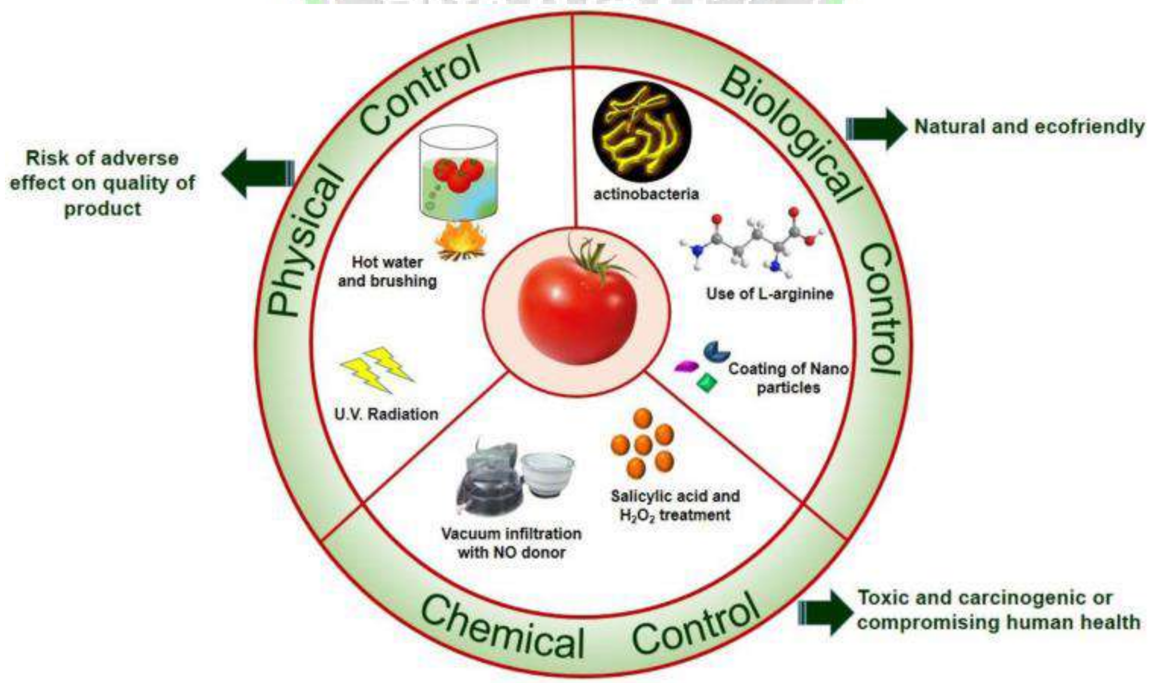
Bacterial pathogens also affect the tomato fruits and are considered one of the destructive postharvest pathogens. Among the bacterial diseases bacterial soft rot and hollow stem, bacterial canker, bacterial speck, and bacterial spot are the dominant ones however the last three diseases affect primarily young developing fruits under moist field conditions. The details of the causative agents, symptoms, and management strategies are mentioned.

Viral diseases

Postharvest decay in tomatoes is also challenged by viral pathogens, although to a much lower extent than their bacterial and fungal partners. A viral infection in tomatoes remains in the "quiescent stage" usually before harvest. However, sudden physiological changes in the host's tissues during the advanced stages of ripening trigger the rapid activation of dormant infections, whose implications are typically manifested during postharvest (Moshe et al., 2016). Thus, the damages occur during the sanitation, and storage time thus compromising the fruit quality than its production yield. On the other hand, a few viral diseases viz. tomato spotted wilt virus, have been one of the most important viral diseases, occasionally leading to plant death (Rossello et al., 1993). Tomato yellow leaf curl is another viral disease of cultivated tomatoes in the tropical and subtropical regions worldwide, and losses up to 100% are most frequent. In many regions, tomato yellow leaf curl is one of the limiting factors in tomato production. The causal agents are a group of Geminivirus species belonging to the genus Begomovirus, named tomato yellow leaf curl virus. Pepino mosaic virus is a rapidly emerging virus that has become one of the most important viral diseases affecting tomato crops. Some of the important viral diseases and with a detailed description of the causative agent, symptoms, favorable conditions, and management strategies is been mentioned in Table.

Approaches to control postharvest pathogen

Various approaches are been adopted to cater to the need for postharvest losses in tomatoes. An overview of all available methods along with the mechanism of action and their impact on the crop is been illustrated.



Physical control

Physical treatments are ancient and cheap methods that have gained much interest in controlling postharvest diseases due to the total absence of residues in the treated product and minimal environmental impact (Usall et al., 2016). Tomato is mainly treated with irradiation, hot water treatment, or integrated physical, chemical, or biological therapy. A low dose of UV-C radiation induces resistance against *Rhizopus* soft rot and extends shelf life, improves firmness, and delays tomato ripening (Liu et al., 1993). Integrated management using biocontrol yeast *Cryptococcus laurentic* and UV-C irradiation are reported to control Postharvest disease of tomato fruit caused by *Botrytis cinerea* or *Alternaria alternata* (Zhang et al., 2013). Hot water rinsing and brushing technique reduces chilling injury and increases resistance against *B. cinerea* in freshly harvested tomatoes (Fallik et al., 2002). Apart from advantages, it has a drawback too, such as low persistence, the risk of adverse effects on the quality of products, or technological problems for commercial application (Usall et al., 2016). Therefore it is advised to combine the physical methods with chemical or biological methods for better efficiency.

Chemical control

Chemical treatments decrease the decay of tomatoes in storage and are considered one of the critical methods to control postharvest losses. Interaction of nitrous oxide (NO) and hydrogen peroxide (H_2O_2) during disease resistance response in Tomato (*Lycopersicon esculentum* cv. *Lichun*) fruits was treated after harvest by vacuum infiltration with NO donor and H_2O_2 scavenger to prevent *Rhizopus nigricans* invasion (Fan et al., 2008). Application of Salicylic acid and Hydrogen peroxide increased fruit rot resistance caused by *Alternaria solani*. Also, applying either salicylic acid or hydrogen peroxide decreases rotten fruit area and increases various enzyme activities and gene expression (Adss et al., 2017). Chemical treatments offer major concerns when used as it is toxic and carcinogenic. It leaves residues to overproduce, thus compromising human and animal health and developing resistance to prevalent pathogens. Also, the chemical method raises environmental concerns as it pollutes agricultural land. Therefore there is a need for new effective postharvest disease control that poses less risk to human health and the environment.

Biological control

Biological control is advantageous over physical and chemical control methods as it naturally controls diseases without causing harm to produce or health/environmental risk.

Biological control methods are getting attention for agricultural sustainability due to the adverse effects on the fields due to continuous exposure to chemical pesticides and weedicides, which also affect the soil characteristics. Indirectly these hazards equally affect human beings as the nutritional content of the crops changes drastically. When we talk about the role of biological agents in preharvest disease management, researchers have demonstrated the disease suppression potential of several plant growth-promoting strains like *Bacillus* sp.,

Pseudomonas sp., *Micromonospora*, *Azotobacter*, etc., having dual functions as plant growth promoters and disease suppressing agents (Babu et al., 2015; Martínez-Hidalgo et al., 2015). Similarly, the impact of biological control agents is also being demonstrated in the postharvest sector. These biological agents have shown significant disease suppression potential in the transport and storage of agricultural commodities.

For example, applying L—Arginine in the Preharvest stage increased postharvest resistance in tomato fruit against *B. cinerea* (Zeng et al., 2011). Coating of Chitosan against *Mucor circinelloides* in combination with carvacrol on tomato rot was studied at storage conditions of 25°C for 12 and 12°C for 20 days. It was found that coating offered resistance against *Aspergillus flavus*, responsible for tomato rot (De Souza et al., 2015). Several researchers have reported the efficient biological control

Biological control methods used to control major postharvest diseases of Tomato.

Disease name	**Causative agent**	**Treatment**	**Reference**
Rhizopus rot	***Rhizopus stolonifer***	Coating of *Cymbopogan citratus* (lemongrass) essential oil and Chitosan delayed the infection of ***R. stolonifer*** in tomato fruit kept at room temperature in storage.	Athayde et al. (2016)
Gray mold	***Cinerea***	***Bacillus subtilis*** L1–21 was used to control gray mold on tomato fruits by adopting plate confrontation and fruit	Bu et al. (2021)

Disease name	Causative agent	Treatment	Reference
		acupuncture method.	
Fruit rot	***Alternaria alternata***	Application of antagonistic yeast and bacteria, isolated from fructoplane and phyllosphere, through injury in tomato fruit infected with ***A. alternata***.	Al-Maawali et al. (2021)
Fruit rot	***Aspergillus flavus***	Coating of Chitosan from ***Mucor circinelloides*** in combination with carvacrol on tomato rot was studied at storage conditions of 25°C for 12 days and 12°C for 20 days. It was found that coating offered resistance against *A. flavus*, which was responsible for tomato rot.	De Souza et al. (2015)
Sour rot	***Geotrichum candidum***	Application of Chitosan and yeast Candida utilize on postharvest tomato fruit rot controlled ***G. candidum***.	Sharma et al. (2006)
Anthracnose	***Colletotrichum coccodes, Colletotrichum gloeosporioides, Colletotrichum dematium***	Yeast transformants as antifungal agents inhibited the decay development of ***C. coccodes*** in postharvest tomato fruit.	Jones and Prusky (2002)
Early blight	***Alternaria solani***	Application of cell suspension ***of Pichia guillieromondii*** on lesions of ***A. solani*** on postharvest Tomato reduced early blight disease.	Zhao et al. (2008)

Disease name	Causative agent	Treatment	Reference
Southern blight	***Sclerotium rolfsii***	Pulverized *Ganoderma* sp. showed fungicidal activity against ***S. rolfsii*** on postharvest tomatoes.	Osemwegie et al. (2010)
Bacterial soft rot	***Erwinia carotovora pv. Carotovora***	Induced antibacterial activity of squid pen Chitosan when applied on tomato lesions infected with ***E. carotovora***	Cuong et al. (2017)

Punja et al. (2016) used *Bacillus subtilis* strain under greenhouse conditions to control the postharvest fruit infection. *B. subtilis* strains were also utilized by Kilani-Feki et al. (2016) for the suppression of *B. cinerea*, the causative agent of tomato fruit rot. Le et al. (2020) evaluated the antibacterial performance of the fermentation supernatant of *Paenibacillus elgii* and its antibacterial compounds (pelgipeptins) against tomato bacterial wilt. Both in vitro and in vivo bioassays indicated an 80.5% reduction of disease incidence in the presence of fivefold diluted fermentation broth. The antibacterial activity of pelgipeptins was found to be comparable to a common bactericide, oxolinic acid, which indicates that the biocontrol agents can be proven equally efficacious to control postharvest disease management in tomatoes.

Endophytes as efficient biocontrol agent

Endophytes are microorganisms that colonize the internal living tissues of the host without causing any apparent disease symptoms (Stone et al., 2000). Broadly they belong to diverse taxa such as bacteria, fungus prostate, Actinomycetes/Actinobacteria, and Archaea (Dheeman et al., 2017). Plants are colonized by microbial communities to enhance plant growth nutrient acquisition and provide biotic and abiotic stress tolerance. These endophytes spend a significant part or even their entire life cycle inside the plant. They get nutrition and shelter from the plant and protect against pathogens and stresses.

Colonization of endophytes

Complex interactions between the plants and the surrounding soil microorganisms in the Rhizosphere (soil-root interface) (Robertson-Albertyn et al., 2017). The aerial parts of the living plant, leaves, buds, flower fruits, and stems, provide a habitat for the microorganisms to enter the plants from the phyllosphere (Beattie, 2002). Endophytes enter from the phyllosphere, ingress into the internal leaf spacing, and colonize the plant (Whipps et al., 2008). Openings of the roots where the roots hair emerges, stomatal openings, wounds, and hydathodes in the shoot are the primary entry points for the endophytes to enter the host plant (Hardoim et al., 2015). Endophytes use the natural due discontinuities in the plant to access the internal plant tissues. Later they modify the cells by producing cellulolytic enzymes, which facilitate this entry and spread with the plant tissues (Compant et al., 2005).

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WOOD APPLE- IMPORTANCE

Article ID: AG-VO4-I04-43

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Introduction

Wood apple is a tropical fruit native to Southeast Asia and belongs to the Rutaceae family. Bael or wood apple is known in India subcontinent from pre-historic time and has been mentioned in the ancient system of medicine. It is grown throughout India as well as in Srilanka, Pakistan, Bangladesh, Burma, Thailand, and most of the Southeast Asian countries. The fruits are delicious but tricky to eat.

Several varieties of wood apple grow in India, of which two types are very popular—yellow bael, which is sweet when ripe, and the kod bael, which is both sweet and sour when ripe. Both have tremendous medicinal value. Many pharmaceutical companies are doing extensive research on this fruit and its plant. It is usually used for household consumption and the uses of wood apple in aspects of food have many forms in each country. The ripe fruit is consumed fresh and also prepared as nectar, squash, sherbet, jam, marmalade, and cream.

In the monsoon of wood apple, a lot of wood apples are found everywhere in India but most of them are spoiled due to the lack of preservation technique. Drying is one of the most economical methods for preservation of wood apple fruit pulp for longer time.

Nutritional compositions

Phytochemical content and nutritional makeup Numerous bioactive substances, including tannins, saponins, alkaloids, terpenoids, flavonoids, and fat steroids, Several wood apple extracts have been shown to contain glycosides, gum mucilage, and fixed oil, which are implicated in the fruit's diverse pharmacological properties. Since ancient times, several plant parts, including the roots, fruits, bark, and leaves, have been used to cure a variety of illnesses, including diarrhea and dysentery. Fruits are said to as protective foods since they are a vital source of vitamins, minerals, carbs, protein, and other nutrients. It also contains many vitamins and minerals including vitamin C, vitamin A, thiamine, riboflavin, niacin, calcium, and phosphorus.

Dietary and nutritional studies have revealed that, in addition to deficiencies in minerals like calcium and iron, many Indians suffer from deficiencies in vitamins A and C. For this reason, fruits should constitute a significant portion of our daily diet. Ripened fruits are highly prized for their medicinal potential in Ayurveda and are known to treat dysentery, diarrhea, and liver disease. They also possess a tart, sweet, aromatic, and refreshing pulp with a good flavor . About 70% of the weight of mature fruit is made up of pulp, and the pulp contains the seeds. It has a moisture content of almost 70%, 7.3% protein, 0.6% fat, 1.9% mineral matter, 2.3% acidity, 7.2% carbohydrates, 0.07% iron, and 0.08% phosphorus. It also has a high riboflavin content (77 mg/100 g).

Uses of the wood apple

Food

The wood apple is a rich in nutrient content but it available on season only. This fruit that can be preserved for human consumption throughout the year. Young wood apple leaves are used in salads in Thailand. Indonesians eat the pulp of the ripe fruit with palm sugar at breakfast. Indians eat the pulp of the ripe fruit with sugar or jiggery for sweet and unripen wood apple with salt for sour. It is used for making chutney and pickles or is blended with coconut milk and palm-sugar syrup and drunk as a beverage. Wood apple pulp is excellent for making jelly.

Medicinal uses

1. The fruit is extensively used in India as a liver tonic and also to treat certain cardiac problems.
2. The half-ripe fruit is perhaps the most effective remedy for dysentry. To treat diarrhea or piles, the mashed pulp of the fruit is used without the seeds.
3. An infusion of wood apple leaves is an effective remedy for peptic ulcers. Wood apple leaves are rich in tannin, which reduces inflammation and help in the healing of ulcers.
4. It is also useful in preventing cancer of the breast and uterus and helps treat infertility caused by insufficiency of the progesterone hormone.
5. The flesh of the mature fruit can also be used to treat stomach upsets among children.

6. The bark of the tree is beneficial for biliousness. It can be taken both in the pulverised or decoction form. The juice of the leaves can also be massaged on the skin rashes caused by biliousness.

7. The root of the bael tree is used as a domestic remedy to check several kinds of ear problems.

8. In Ayurveda, all parts of the wood apple plant are used to cure snake bites.

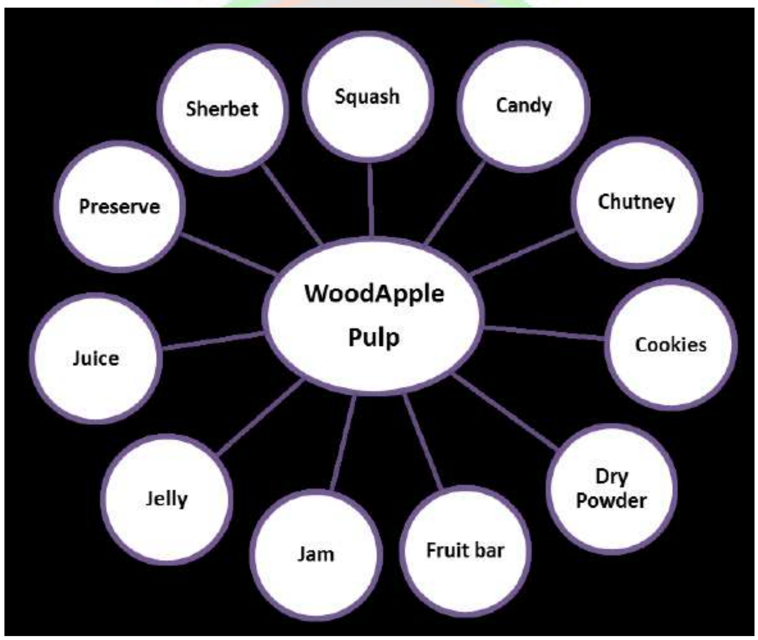
9. 100 gm of the fruit's pulp provides 140 calories and is therefore a good energy booster.

10. The wood apple is used to treat kidney ailments like stones.

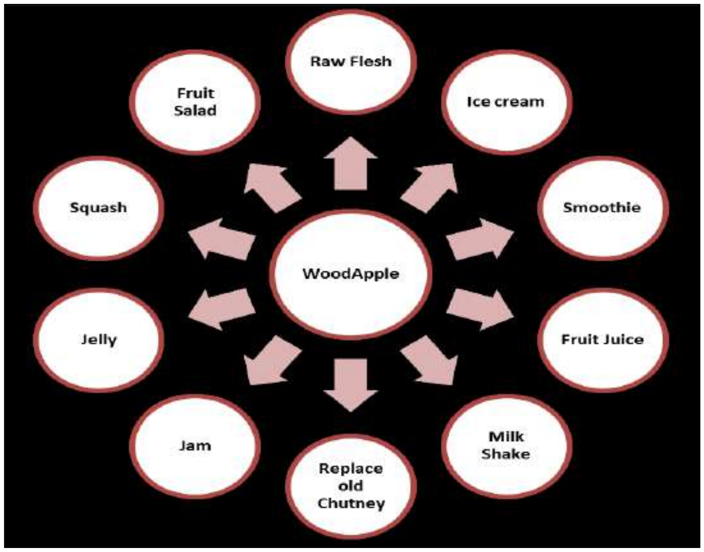
11. The leaves of the wood apple are used to prevent and treat cold and other respiratory disorders. The fruit is also effective in relieving sore throats and chronic coughs.

12. The wood apple contains carotene, which is beneficial for the eye.

13. An extract of the bark of the tree is used to prevent sun burn.



Prevents cancer: Wood Apple shows anticancer activity by reducing the risk of cancer and inflammation in the body, it causes the death of cancer cells, particularly those affecting breast and skin.Anti-ageing benefits: Vitamin C present in wood apple which supports natural collagen synthesis. It helps to reduce the oxidative damage from ultraviolet sun exposure, and skin quality can be maintained for years. Diets high in antioxidant nutrients are among the best for excreting anti-ageing benefits and are something wood apple excels at.



Promotes detoxification: Wood apples are equipped with riboflavin and thiamine chemicals, so they effectively detoxify the body. In addition, wood apples help to protect the liver from inflammation.

Supports respiratory health: Consumption of wood apple can assist with freebreathing owing to decongestant properties, along with cough suppressant and mucolytic actions to clear the lungs catarrh.

Antimicrobial activity: The Wood apple fruit contains flavonoids which give antioxidant property, saponins which are responsible for foaming and anti-fungal property, antimicrobial agent which possesses properties against the replication of bacteria and viruses.

Energy Booster: A single wood apple delivers around 25 g of fast-digesting carbohydrates, which helps provide energy to the body when needed the most. However, it is not suitable for patients suffering from diabetes as it provides high sugar levels.

Wound healing agent: Wood apples may promote the healing of bones as they contain anti-inflammatory agents. They also possess the ability to inhibit the accretion of pathogens. In addition, it also can stimulate the production of collagen, which is a protein responsible for the structure of the scar.

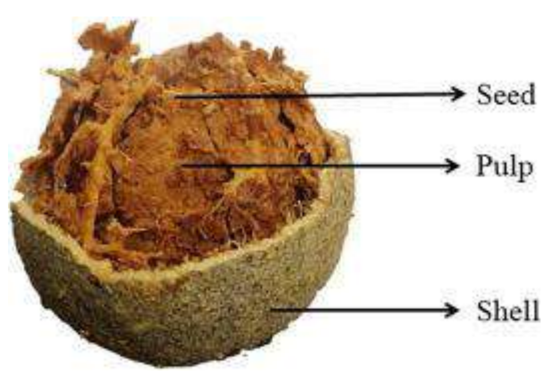
Blood purifier: A small quantity of wood apple helps in purifying the blood and helps in removal of toxins. This, in turn, has the effect of reducing the load on the liver and kidneys. **Anti-Diabetic activity**: Wood apple fruits which contains polyphenols and flavonoids, which have been shown to have hypoglycemic effects and helps in lowering blood sugar levels in diabetics. It is not just the fruit, but also other parts of the tree that have medicinal properties. For instance, the bark has something called Feronia gum, which can balance sugar levels in the blood by adjusting glucose and insulin level. Wood apple used for the treatment of nausea, vomiting, acts as antidote against some poisons, improves the taste perception, beneficial for cardiac muscles, and clears the phlegm from the throat, dyspnea and thirst.

Other uses

1. The fruit's shell is fashioned into snuffboxes and other small containers.
2. Interestingly, in addition to its edible and medicinal properties, the gum from the trunk and branches is used as glue. The exudation is profuse after the rainy season.
3. The gum, mixed with lime, is used to waterproof wells and walls. It also protects oil paintings when added as a coat onto the canvas.
4. The fruit rind yields oil that is popular as a fragrance for hair; it also produces a dye used to colour silks and calico.
5. The wood is yellow-gray or whitish, hard, heavy, durable, and hence used in construction, patternmaking, agricultural implements, rollers for mills, carving, rulers and other products. It also serves as fuel.
6. The wood apple's pulp has a soap-like action, which resulted in it being used as a household cleaner for hundreds of years.

Value added products from wood apple

If the wood apple fruits are harvested when they are still slightly unripe, they can be stored at room temperature to allow them to ripen naturally. This process usually takes around 5-7 days. Once the fruits have reached the desired ripeness, they can be consumed or further processed.



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HARNESSING THE POTENTIAL OF AI-DRIVEN ANALYTICS

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Abstract

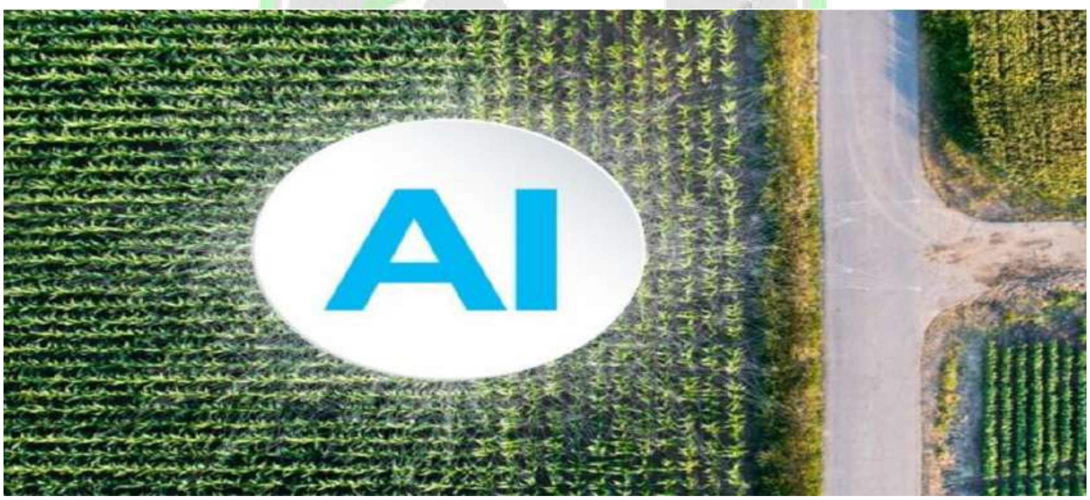
In the realm of agriculture, the convergence of AI-driven analytics heralds a new era of optimization and efficiency. Through the lens of digital farming, this article explores how AI technologies empower data-driven decision-making, revolutionizing crop monitoring, precision agriculture, and predictive analytics. By harnessing AI algorithms, farmers gain unprecedented insights into crop health, soil conditions, and market dynamics, enabling them to optimize resource allocation and anticipate future trends. However, widespread adoption faces challenges such as data accessibility and privacy concerns. Nevertheless, collaborative efforts across stakeholders promise to unlock the transformative potential of AI-driven analytics, shaping a future of sustainable farming practices and enhanced productivity.

Keyword: AI-driven analytics, Optimization, Digital Farming, Data-driven decision

Introduction

In an era of rapid technological advancement, agriculture finds itself on the cusp of a profound digital transformation. Faced with the challenge of feeding a growing global population amidst escalating demands, the agricultural sector is compelled to innovate to enhance productivity and efficiency while mitigating environmental impact. Artificial intelligence (AI) emerges as a pivotal technology driving this evolution, steadily permeating diverse facets of agricultural practices. Particularly, AI-driven analytics emerge as a transformative force, bestowing farmers with actionable insights gleaned from vast troves of data. By harnessing AI algorithms, farmers can now make informed, data-driven decisions, steering their operations towards optimized outcomes and heightened efficiency.

The integration of AI-driven analytics into agriculture marks a significant departure from traditional practices, ushering in an era of precision and foresight. With global populations burgeoning and resources dwindling, the imperative to produce more with less has never been more pressing. AI empowers farmers to transcend conventional limitations, offering real-time insights into crop health, soil conditions, and environmental factors. Through predictive analytics, AI augments decision-making, enabling farmers to anticipate future trends and adapt their strategies proactively. As agriculture embarks on this digital journey, the fusion of AI-driven analytics promises not only to optimize productivity and efficiency but also to forge a path towards sustainable farming practices that resonate with the needs of the planet and its inhabitants.



The Rise of AI in Agriculture

AI-driven analytics in agriculture involve the utilization of advanced algorithms and machine learning techniques to analyze vast amounts of agricultural data. This data encompasses a wide range of variables, including weather patterns, soil composition, crop health, and yield predictions. By collecting and analyzing this data, AI algorithms can identify patterns, trends, and anomalies, providing farmers with valuable insights into their operations.

Table 1: Applications of AI-Driven Analytics in Agriculture

Application	Description
Crop Monitoring and Management	Utilizes sensors, drones, and satellite imagery to collect real-time data on crop health, soil moisture levels, and other parameters.
Precision Agriculture	Generates precise prescriptions for inputs (such as fertilizers, pesticides, and water) by integrating data from various sources.
Predictive Analytics	Utilizes historical data and current trends to forecast future outcomes, aiding decision-making in crop selection and planting strategies.

Enhancing Crop Monitoring and Management

In an era where technological advancements are revolutionizing every sector, agriculture stands at the threshold of a digital transformation. With the growing global population and the increasing demand for food, the agriculture industry is under immense pressure to enhance productivity and efficiency while minimizing environmental impact. One of the key technologies driving this transformation is artificial intelligence (AI), which is being increasingly integrated into various aspects of agricultural practices. In particular, AI-driven analytics are proving to be a game-changer, empowering farmers with actionable insights to make data-driven decisions and optimize their operations for better outcomes.

One of the primary applications of AI-driven analytics in agriculture is in crop monitoring and management. By deploying sensors, drones, and satellite imagery, farmers can collect real-time data on various aspects of crop health, soil moisture levels, temperature, humidity, nutrient levels, and pest infestations. This multifaceted data collection approach enables farmers to comprehensively monitor the conditions of their crops and make timely decisions regarding irrigation, fertilization, and pest control. AI algorithms play a crucial role in analyzing this data, identifying patterns and anomalies that might indicate issues such as nutrient deficiencies or pest outbreaks. By detecting these problems early on, farmers can take proactive measures, such as adjusting irrigation schedules or applying targeted treatments, to mitigate potential losses and optimize yields. Ultimately, this proactive approach to crop monitoring and management not only improves productivity but also promotes sustainable farming practices by reducing the reliance on chemical inputs and minimizing environmental impact.

Precision Agriculture: Optimizing Resource Allocation

Precision agriculture stands as a pioneering frontier where AI-driven analytics wield transformative power. By amalgamating data from an array of sources, including sensors monitoring soil conditions, GPS technology tracking field boundaries, and comprehensive historical yield data, AI algorithms intricately analyze the agricultural landscape. This comprehensive analysis enables the generation of precise prescriptions for inputs such as fertilizers, pesticides, and water, tailored to the unique needs of each specific area within a field.

The targeted allocation of resources facilitated by AI not only fosters maximized crop yields but also orchestrates a reduction in input costs and a mitigation of environmental impact. Through optimized resource utilization, AI-driven precision agriculture minimizes wastage and environmental degradation, steering clear of over-application and reducing the likelihood of runoff and leaching. Furthermore, the integration of predictive analytics empowers farmers to transcend reactive practices, allowing them to anticipate future trends and adapt their management strategies preemptively.

By proactively aligning their approaches with emerging trends and evolving conditions, farmers bolster the sustainability of their operations. This forward-thinking ethos permeates precision agriculture, embodying a commitment to holistic stewardship of resources and environmental preservation. Ultimately, the convergence of AI-driven analytics and precision agriculture represents a beacon of hope for sustainable agricultural practices, ushering in an era where productivity and environmental responsibility harmoniously coexist.

Empowering Decision-Making with Predictive Analytics

Predictive analytics stands as a transformative force in agricultural decision-making, revolutionizing the way farmers plan for the future. By leveraging historical data and current trends, AI algorithms have the capability to forecast outcomes crucial to agricultural success. Factors such as weather patterns, market dynamics, and crop performance data are meticulously analyzed to generate precise predictions regarding yields, market prices, and optimal planting times. Equipped with this foresight, farmers are empowered to make informed decisions that shape their operations strategically.

This predictive capability enables farmers to optimize various aspects of their agricultural practices. From selecting the most suitable crops to determining the ideal planting times, predictive analytics provides invaluable guidance that maximizes profitability and mitigates risks. By anticipating market trends and adjusting planting strategies accordingly, farmers can capitalize on favorable conditions and minimize the impact of adverse events such as extreme weather or market fluctuations. Additionally, predictive analytics aids in the optimization of marketing initiatives, ensuring that farmers can effectively position their products to meet consumer demand and achieve the highest possible returns.

In essence, predictive analytics represents a critical tool in the modern farmer's arsenal, offering unparalleled insights into the future of agriculture. By harnessing the power of AI to forecast outcomes with accuracy and precision, farmers can navigate the complexities of agricultural production with confidence and foresight. As the agricultural landscape continues to evolve, predictive analytics will remain a cornerstone of decision-making, guiding farmers towards greater profitability, resilience, and sustainability in the face of uncertainty.

Overcoming Challenges and Ensuring Adoption

Despite its immense potential, the widespread adoption of AI-driven analytics in agriculture faces several challenges, including data accessibility, infrastructure limitations, and concerns regarding data privacy and security. Addressing these challenges requires concerted efforts from stakeholders across the agriculture value chain, including governments, technology providers, and farmers themselves. Initiatives such as data sharing platforms, infrastructure development projects, and regulatory frameworks can facilitate the seamless integration of AI-driven analytics into agricultural practices, unlocking its full potential to revolutionize the way we farm.

Conclusion

AI-driven analytics redefine agriculture, optimizing resource management, boosting yields, and mitigating risks through data-driven decisions. Collaboration and investment are essential to fully harness AI's potential in shaping a future of farming that prioritizes efficiency, resilience, and sustainability. In embracing the era of digital farming, AI-driven analytics promise to revolutionize agricultural practices, paving the way for a more prosperous and sustainable food system.

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HORMONAY AT ODDS: NAVIGATING THE CLASH OF NATURE AND CIVILIZATION IN HUMAN-ANIMAL CONFLICT

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Abstract

Human-animal conflict refers to situations where there is direct or indirect confronation between humans and wild animals, resulting in negative impacts on both parties. Managing human-animal conflict is crucial for the conservation of wildlife and the well-being of human communities living in or near wildlife habitats. It is a multifaceted and increasingly pressing issue in today's world. As human population expand and habitat shrinks, conflicts between human and wildlife have become more frequent and intense. One of the primary drivers of conflict is habitat loss and fragmentation. As human settlements expands into natural habitats, wildlife is pushed into smaller and more restricted areas, leading to increased encounters and conflicts with humans. The impacts of conflict are far-reaching and affect both humans and wildlife. On human side, such as conflicts to property and even loss of life. For wildlife, it may cause injury, stress and displacement. Addressing human-animal conflict requires multifaceted approach that considers the need of both humans and animals. One key strategy is habitat conservation and restoration, aimed at preserving and expanding natural habitats to reduce human-wildlife interactions. Furthermore, employing non-lethal methos of wildlife management, education and awareness-raising programs and implementations of laws are also essential to save the life of humans and animals.

Introduction

The clash between nature and civilization, particularly concerning human-animal conflict, is a multifaceted and increasingly pressing issue in today's world. As human population expand and habitats shrink, conflicts between human and wildlife have become more frequent and intense. Human-animal conflict refers to situations where there is direct or indirect confronation between humans and wild animals, resulting in negative impacts on both parties, These conflicts can arise due to various factors such as habitat destruction, competition for resources, human encroachment into wildlife territories, and behavioral changes in animals due to human activities. Examples include crop raiding by elephants, predation on livestock by carnivores, attacks on humans by large predators, and destruction of property by wildlife. Managing human-animal conflict is crucial for the conservation of wildlife and the well-being of human communities living in or near wildlife habitats. This article delves into the complexities of this clash, exploring its causes, impacts and potential solutions.

UNDERLYING CAUSES FOR HUMAN-ANIMAL CONFLICT

Human-animal conflict arises due to a variety of reasons, primarily stemming from the interaction and overlap between human activities and wildlife habitats. Here are some common reasons for human-animal conflict,

1. **Habitat Loss and Fragmentation:** Habitat loss and fragmentation are key environmental challenges that have profound implications for biodiversity, ecosystem functioning, and human well-being. As human populations continue to grow, expand, and develop, natural habitats around the world are being increasingly altered, degraded, or destroyed. This process not only directly impacts wildlife species but also disrupts the intricate web of interactions that sustain healthy ecosystems. As human populations expand, natural habitats are increasingly converted into agricultural land, urban areas, or infrastructure development. This process leads to habitat loss and fragmentation, forcing wildlife into smaller and more isolated areas, where they often come into conflict with humans.

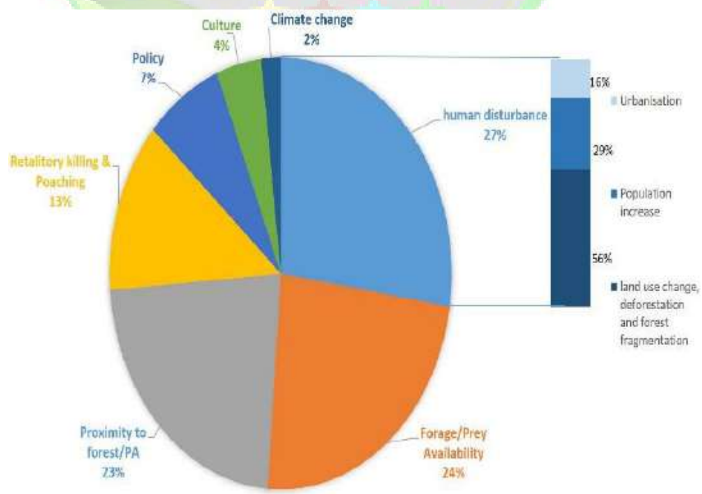
   "Habitat loss is the primary cause of species extinction worldwide. The more we fragment the forest, the more species we are likely to lose." - Paul R. Ehrlich
2. **Competition for Resources:** Competition for resources is a universal phenomenon in the natural world, driving the interactions and dynamics of ecosystems. It arises when multiple organisms, including humans and wildlife, vie for limited resources essential for their survival and growth. Among the most critical resources are food, water, shelter, and space, which form the basis of life-supporting systems. In recent times, the escalating human population and associated activities have intensified competition for resources between humans and wildlife.

This competition manifests in various forms, from conflicts over grazing lands and water sources to disputes over crop raiding and habitat encroachment. Such competition not only impacts the ecological balance but also poses challenges for conservation efforts and sustainable coexistence.

3. **Livestock Grazing:** Livestock grazing, the practice of allowing domestic animals such as cattle, sheep, and goats to feed on natural or cultivated vegetation, has been integral to human livelihoods and food production for centuries. While grazing provides sustenance and economic benefits for human communities, it also has profound impacts on ecosystems, wildlife habitats, and the dynamics of human-animal interactions. Grazing activities can exert pressure on vegetation, soil, water resources, and wildlife, leading to challenges such as habitat degradation, soil erosion, water pollution, and conflicts with wildlife species. Domestic livestock grazing in or near wildlife habitats can attract predators looking for easy prey. This can lead to conflicts between livestock owners and predators, such as wolves, lions, or bears, which may attack livestock to meet their dietary needs.
4. **Human Food Sources:** Human food sources play a crucial role not only in sustaining human populations but also in influencing human-animal interactions and conflicts. In many cases, food resources intended for human consumption can inadvertently attract wildlife, leading to conflicts, property damage, and safety concerns for both humans and animals. In areas where natural prey is scarce, wild animals may turn to human food sources, such as garbage dumps or agricultural fields, leading to conflicts with humans over food and property damage. When wildlife species access these food sources, they may cause damage to crops, infrastructure, or property, and in some cases, pose risks to human safety.
5. **Infrastructure Development:** Infrastructure development is a cornerstone of modern society, facilitating economic growth, connectivity, and improved standards of living. Infrastructure plays a vital role in shaping the built environment and supporting human activities. However, the rapid pace of infrastructure development also raises complex challenges and considerations, particularly in terms of environmental impact, land use, and natural resource utilization. Infrastructure projects often require significant land clearance, alteration of natural landscapes, and the consumption of resources such as land, water, and energy.
6. **Illegal Wildlife Activities:** Illegal wildlife activities represent a pervasive and escalating threat to global biodiversity, ecosystems, and the sustainable use of natural resources. These

activities encompass a range of illicit practices, including poaching, illegal wildlife trade, habitat destruction, and trafficking of endangered species, driven by lucrative markets, demand for exotic products, and socio-economic factors. The impact of illegal wildlife activities extends far beyond the direct exploitation of wildlife. It fuels corruption, organized crime networks, and insecurity, undermining conservation efforts, environmental sustainability, and the rule of law. Moreover, it poses risks to human health, as wildlife trafficking can facilitate the spread of zoonotic diseases and threaten public health security.

7. **Climate Change:** Climate change is one of the most pressing and complex challenges facing humanity and the planet today. It refers to the alterations in global climate patterns, including temperature fluctuations, shifts in precipitation, sea level rise, and extreme weather events, all of which are attributed to human-induced changes in atmospheric composition. The primary driver of contemporary climate change is the excessive emission of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from human activities such as burning fossil fuels, deforestation, industrial processes, and agriculture. These gases trap heat in the Earth's atmosphere, leading to the warming of the planet and disruption of climate systems. Climate change-induced shifts in habitats and weather patterns can force wildlife to move into new areas in search of suitable conditions, bringing them into closer contact with human settlements and increasing the potential for conflicts.



8. **Human Behavior and Attitudes:** Human behavior and attitude towards the environment have profound implications for sustainability, conservation, and the well-being of ecosystems and species. Positive attitudes towards conservation, biodiversity, and environmental stewardship can lead to responsible behaviors, conservation-oriented decision-making, and

efforts to minimize ecological footprints. However, negative attitudes, such as indifference, apathy, or anthropocentrism (placing human needs above ecological concerns), can contribute to unsustainable practices, overexploitation of resources, habitat destruction, and biodiversity loss. Addressing human behavior and attitude is therefore essential for promoting environmental sustainability, biodiversity conservation, and resilience to environmental challenges. Human behaviors such as feeding wildlife, improper waste disposal, and fear-based reactions to wildlife presence can also contribute to conflicts by altering animal behavior and increasing dependency on human-provided resources.

IMPACTS OF HUMAN-ANIMAL CONFLICT

1. **Loss of Human Lives and Injuries:** One of the most immediate and tragic impacts of human-animal conflict is the loss of human lives and injuries caused by wildlife attacks. Large predators, such as tigers, lions, and bears, can pose serious threats to human safety in areas where their habitats overlap with human settlements.
2. **Livelihood and Economic Losses:** Human-animal conflict can result in significant economic losses for communities dependent on agriculture, livestock rearing, and natural resources. Crop raiding by elephants, deer, or monkeys can devastate farmers' crops, leading to food insecurity and financial hardships.
3. **Property Damage:** Wildlife activities, such as digging, foraging, or nesting, can cause damage to property, infrastructure, and vehicles. For example, elephants may damage fences, buildings, or crops during their movements, leading to costly repairs and losses.
4. **Livestock Depredation:** Predation on livestock by carnivores such as wolves, big cats, or hyenas can result in losses for livestock owners, impacting their livelihoods and exacerbating conflicts between communities and wildlife.
5. **Psychological Stress:** Human-animal conflict can also cause psychological stress and trauma for individuals and communities living in conflict-prone areas. Fear of wildlife attacks, sleep disturbances, and anxiety about crop or property damage are common experiences in such contexts.
6. **Conservation Concerns:** On the wildlife side, human-animal conflict can have detrimental effects on endangered species and biodiversity conservation efforts. Retaliatory killings of predators, habitat fragmentation, and disruption of natural behaviors can threaten the survival of vulnerable species.

7. **Ecosystem Imbalance:** Human-animal conflict can disrupt ecological processes and lead to imbalances in ecosystems. For example, overgrazing by herbivores due to habitat loss can degrade vegetation and impact soil health, affecting other wildlife species and ecosystem services.
8. **Social Tensions:** Human-animal conflict can also lead to social tensions and conflicts within communities, especially when decision-making about wildlife management and conflict resolution is contentious. Different stakeholders may have conflicting interests and perspectives, leading to disputes and divisions.

STRATEGIES FOR HUMAN-ANIMAL CONFLICT

Addressing human-animal conflict requires a multifaceted approach that considers the needs and perspectives of both humans and wildlife. Here are some of the strategies can be implemented to mitigate human-animal conflict:

1. **Habitat Conservation and Restoration:** Protecting and restoring natural habitats for wildlife is essential to reduce human-wildlife interactions and conflicts. This includes establishing wildlife corridors, protected areas, and buffer zones to allow for the movement of wildlife while minimizing conflicts with human settlements.
2. **Land-Use Planning and Zoning:** Implementing effective land-use planning and zoning regulations can help minimize conflicts by designating suitable areas for human development and wildlife habitats. This can include identifying wildlife-sensitive zones and setting aside areas for conservation purposes.
3. **Non-Lethal Wildlife Management:** Utilizing non-lethal methods for managing wildlife, such as deterrents, fencing, noise devices, and behavior modification techniques, can help prevent conflicts without resorting to lethal control measures. Non-lethal approaches are more humane and can be effective in deterring wildlife from human-inhabited areas.
4. **Community Engagement and Education:** Engaging local communities in wildlife conservation efforts, providing education and awareness about the importance of coexistence, and promoting sustainable practices can foster greater understanding and tolerance towards wildlife. Community-based conservation initiatives that involve stakeholders in decision-making processes can lead to more effective conflict resolution strategies.
5. **Livelihood Diversification:** Supporting livelihood diversification options for communities

living in conflict-prone areas can reduce dependency on natural resources that attract wildlife. Providing alternative income opportunities, such as ecotourism, sustainable agriculture, or small-scale enterprises, can alleviate pressure on wildlife habitats and reduce conflicts.

6. **Early Warning Systems:** Developing and implementing early warning systems, such as alert mechanisms for crop raiding or livestock depredation, can help communities take proactive measures to prevent conflicts. Timely information can enable farmers and herders to protect their crops and livestock effectively.
7. **Collaboration and Partnerships:** Collaborating with various stakeholders, including government agencies, conservation organizations, research institutions, and local communities, is crucial for developing comprehensive solutions to human-animal conflict. Partnerships can leverage resources, expertise, and knowledge to implement effective management strategies.
8. **Policy and Legal Frameworks:** Enacting and enforcing policies, laws, and regulations that protect wildlife, promote sustainable land use practices, and incentivize coexistence can provide a framework for managing human-animal conflict. This includes measures such as wildlife conservation acts, compensation schemes for loss of livelihood or property due to wildlife, and regulations on waste management to reduce attractants for wildlife.

MEASURES TAKEN BY THE GOVERNMENT

1. **The Wildlife Protection act, 1972:** The Wildlife Protection Act is a comprehensive legislation enacted to protect and conserve wildlife species and their habitats in India. It aims to regulate hunting, poaching, trade, and exploitation of wildlife, as well as establish protected areas and promote conservation efforts. The Wildlife Protection Act was first enacted in 1972 and has since been amended to strengthen conservation measures and address emerging conservation challenges.
2. **The National Wildlife Action Plan, 2002:** it is a strategic document that outlines conservation priorities, strategies, and actions for the protection and sustainable management of wildlife and biodiversity in a country. Several countries, including India, have developed National Wildlife Action Plans to address conservation challenges, promote sustainable development, and safeguard natural heritage.

3. **Project Tiger:** Project Tiger is a centrally sponsored scheme, launched in 1973. It provides havens for tigers in the country's national parks.
4. **Project Elephant:** It is a centrally sponsored scheme and was launched in February 1992 for the protection of Elephants, their habitats and corridors.
5. **National Disaster Management Authority (NMDA):** The National Disaster Management Authority (NDMA) is a pivotal governmental body tasked with the strategic planning, coordination, and implementation of disaster management initiatives in a country. It serves as the central agency responsible for formulating policies, guidelines, and action plans aimed at reducing the risk of disasters, enhancing preparedness, coordinating response efforts, and facilitating recovery and rehabilitation in the aftermath of disasters. The role of NDMA is crucial in safeguarding lives, protecting infrastructure, minimizing economic losses, and promoting resilience in the face of diverse natural and man-made hazards.

Conclusion

In conclusion, human-animal conflict represents a complex and multifaceted challenge that requires holistic approaches and collaborative efforts to address effectively. The impacts of human-animal conflict on both humans and wildlife are significant, ranging from loss of lives and livelihoods to ecological imbalances and conservation concerns. However, through proactive measures and sustainable strategies, it is possible to mitigate these impacts and promote coexistence between humans and wildlife. Key solutions include habitat conservation and restoration, land-use planning, non-lethal wildlife management techniques, community engagement and education, livelihood diversification, early warning systems, collaborative partnerships, and policy and legal frameworks. By implementing these solutions and fostering a deeper understanding of the interconnectedness between human activities and wildlife habitats, we can work towards minimizing conflicts, conserving biodiversity, and fostering harmonious relationships between humans and the natural world. Ultimately, finding a balance between human needs and wildlife conservation is essential for ensuring the well-being of ecosystems, maintaining ecological integrity, and preserving the rich diversity of life on Earth for future generations. Through concerted efforts, stakeholder collaboration, and sustainable practices, we can navigate human-animal conflict towards coexistence and shared prosperity.

"The greatness of a nation and its moral progress can be judged by the way its animals are treated"- Mahatma Gandhi

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NATURAL FARMING –PHILOSOPHY AND CURRENT STATUS

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Introduction

Natural farming is a kind of farming that is chemical free which is complimented by the deep rooted human and Indian culture. Natural Farming can be defined as "chemical- free and livestock based farming" (NITI Ayog, Natural farming).Hon'ble Prime Minister while addressing the nation from the Red Fort on Independence Day in 2019 said "as a farmer, as a child of this soil, I have no right to damage its health". He also mentions that, ICAR has developed a geo-referenced organic carbon map of India and has identified 88 bio-control agents and 22 bio-pesticides that can promote organic agriculture.

At the time of chemical farming revolution, the fruitful results of non sustainable agriculture made the scientists and famers believe that, that was the end of hunger. But eventually, the side negative effects came into picture and within not much time, they became reality. In this context, this article discusses history, philosophy, aims, different components and challenges of Natural farming.

History and Philosophy of Natural Farming:

Mokichi Okada, Japanese orient philosopher, proposed the philosophy of nature farming. an alternative for organic farming. Natural farming mainly aims at the farming practices with minimal or no human or chemical intervention.

Masunobu Fukuoka (1913-2008) was a Japanese farmer and philosopher, laid foundation for the concept of 'natural farming' or 'do-nothing farming.' The Fukuoka's methodology focusses on sustaining the natural resources and its conditions instead of polluting the nature for maximizing the outputs. Fukuoka is well known for his world famous texts 'The One-Straw Revolution' and 'The Road Back to Nature' inspiring many enthusiasts.

Fukuoka's philosophy encourages Farming in harmony with nature- living in harmony with nature in his book 'The One-Straw Revolution'.

Masanobu Fukuoka throwing a seed ball at the workshop in 2002.

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Current Scenario of Natural Farming in India:

In India, the idea of natural farming was pulled into light by Shri Subhash Palekar, for which he was honoured with Padma Shri in 2016. Many states have taken up initiatives for natural farming promotion Andhra Pradesh, Gujarat, Himachal Pradesh, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh and Tamil Nadu are among the leading states. As of now more than 10 lakh ha. area is covered under natural farming in India.

In India currently 11 states practicing natural farming with a total are of 6.5 Lakh Ha covered (NITI Ayog, Natural fariming). Among the practicing states, Andhra Pradesh stands first followed by Gujarat and Madhya Pradesh.

National mission on sustainable agriculture (NMSA) launched Bharatiya Prakritik Krishi Paddhati (BPKP) in 2019 under the Paramparagat Krishi Vikas Yojana (PKVY). This scheme has a total outlay of Rs. 4645.49 crore for a period of six years.

Aims and Objectives

The aim of the natural farming is achieving sustainable agricultural production, that could feed the largely populated country like India. The fundamental objectives of natural farming can be summarized as below (National Mission On Natural Farming Management And Knowledge Portal).

• Preservation natural flora and fauna

• Restoration soil health and fertility and soil's micro biome

• Conservation of crop diversity and bio diversity

• Sustainable land use and land use planning

• Promoting natural beneficial insects, animals and microbes in soil for nutrient recycling and biological control of pests and diseases

• adoption of of local breeds for livestock integration

• Use of natural / local resource-based inputs such as seeds and other farming inputs.

• Reduce input cost of agricultural production and improving BC ratio of small and marginal farmers.

Principles of natural farming

The natural farming concept relays majorly upon the principles *viz.*, Principle of healthiness, ecological principle (Natural farming greatly relays up on the ecologically based diversified farming systems such as integrated farming system, integrated nutrient management, integrated pest management and integrated disease management.) and Principle of fairness.

Components of Natural Farming:

Among different components of natural farming, Beejamrit, Jeevamrit, mulching and whapasa are very important (blog, Forum IAS, 2022). Beejamrit is a process of coating or treating the seeds with cow dung, urine and lime based formulations. Jevamrit enhances the fertility of soil using cow urine, dung, flour of pulses and jaggery concoction. Whapasa involves activating the soil using earth worms resulting to water vapor condensation.

Pest control and disease control in Natural farming

Seed borne diseases, insect- pest infestations can be managed by Beejamrita seed treatment. Darekastra/Paudhastra solution is used to control sucking insect-pests and young caterpillars attacking fruits and vegetables. Brahmastra solution is used to control sucking insect-pests and older larvae infesting crops. Agneyastra solution is used against pests like fruit borers, root borers and leaf folders that are hidden inside fruits, roots and leaves of plants. Dashparni solution is used to control all types of insect-pests infesting crops, fruits and vegetables. It takes care of the difficult to control pests. Neemastra is used to control sucking insect-pests and young caterpillars attacking various crops.

Reasons why we have to shift to Natural farming

Practice of natural farming has these following advantages at farmer level and national level.

- Reduces the nature pollution with minimal carbon and nitrogenfoot print
- Improves yield and outcome and returns per harvest.
- Rejuvenates soil health and reduces human health hazards.
- Improves soil microbial health, diversity.
- Generates employment through enterprises, value addition, marketing mostly by local based marketing.
- Production of jivamrit and beejamrit, Can be possible by integration of livestock in natural farming.

Challenges

The natural farming practices are questioned by agricultural scientists about its potentiality to feed largely populated countries like India, China. The quality control and maintenance of authenticity for naturally produced and marketed farm products remains a challenge for Government. Standardization of Certification process is another hurdle in India. Limited awareness of farmers, lack of production and marketing ecosystem are major challanges.

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PUBLIC–PRIVATE PARTNERSHIPS (PPPS) IN INDIAN AGRICULTURE

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Introduction

Public–Private Partnerships (PPPs) in agricultural research and development are increasingly viewed as an effective means of conducting advanced research, developing new technologies, and deploying new products for the benefit of small-scale, resource-poor farmers and other marginalized social groups in developing countries. PPPs as any research collaboration between public- and private-sector entities in which partners jointly plan and execute activities with a view to accomplishing agreed-upon objectives while sharing the costs, risks, and benefits incurred in the process.

Public-private partnerships (PPPs) are essential for advancing agriculture to meet global challenges in food security. They help widen access to technology and link farmers to markets. By combining strengths, the partners can make better progress than on their own.

The primary objective of the PPP initiative is to enhance the income of small farmers by creating additional value, from provisioning of quality inputs, technology extension to market linkages, and value addition. PPP initiatives are also expected to lead to modernizing agriculture practices, promoting research in climate resilient crops, developing agriculture and rural infrastructure, and increasing agricultural exports. A particular objective is to assist the States to unlock the full potential of their respective agro-climatic regions, and wide variety of agri-produce and help producers to integrate better with domestic and export markets.

Public Private Partnership Approach

In India, the agriculture produce is distributed according to geographical proficiency. Such distribution can be termed as the production hubs for the particular crop. Successful replication of PPP models across various production hubs for key commodities can lead to the evolution of Indian agriculture from inefficient, supply driven, low value business scenario to an organized, high-tech, demand-led and high-value orientation.

Agriculture investments and increasing gross capital formation in agriculture are key to modernizing the Agriculture sector. Combining public investments, in the form of various Central Government and State Government initiatives in agriculture along with the Private sector investment, can be a force multiplier for the agriculture sector. The Government is keen to incentivize PPP initiatives in the Agriculture sector to improve yields, reduce losses and enhance farmer incomes. PPP initiatives will crowd in private capital in agriculture, leverage public investment and align the Central and State Governments, the Private sector, and farmers in a shared vision of dynamic and value-added growth in the sector. PPP initiatives will also lead to the convergence of various schemes to benefit farmers and improve their impact.

Features of the PPP Model

- The model would help the farmers to shorten the cost of cultivation by reducing the post-harvest losses, transportation costs, energy losses by maximizing the optimum use of available resource, enhancing environment quality and earning better profit from better quality product.
- The higher returns can be ensured through high quality product, off-season availability, and through enhancing the productivity, which would help the government to meet the issue of food security to certain extent. The suggested model will create a market place, which works, in its natural form where large number of buyers and large number of sellers participate in transactions and decide price without monopoly of any dominant market player.
- The present system does not come up with cultural change, technological advancements and professional expertise of different stakeholders. IT applications have opened various dimensions of backward and forward linkages, which will ensure transparency and efficiency. Even various opportunities of collaborative arrangements with exchequers in PPP model, the farmers may not prefer to take risk in dealing with APMCs.

Key aspects of PPPs in Agriculture

- Infrastructure Development: PPPs can be used to develop agricultural infrastructure such as irrigation systems, storage facilities, and transportation networks.
- Technology Transfer: Collaborations between governments and private companies can facilitate the transfer of technology and expertise to improve agricultural practices, increase productivity, and enhance resilience to climate change.
- Value Chain Development: PPPs can support the development of agricultural value chains by improving market access, strengthening linkages between producers and buyers, and promoting inclusive business models.
- Research and Development: Governments often partner with private sector entities to fund research and development projects aimed at addressing agricultural challenges, such as crop diseases, soil degradation, and water scarcity.
- Capacity Building: PPPs can involve initiatives to build the capacity of farmers, extension workers, and other stakeholders through training programs, knowledge sharing, and technical assistance.
- Policy Support: Governments may collaborate with private sector organizations to develop and implement policies that create an enabling environment for agricultural investment, innovation, and growth.

Dimensions of PPP in Indian Agriculture

- India is considered as one of the fastest growing economies in the world with an annual growth rate of around 8 per cent while, the average annual growth rate in agriculture is still at the slowest pace of growth (2.7 %).
- Innovations through partnerships between public and private sectors can be a possible solution to improve the agricultural sector. As an initiative, Maharashtra was the first state to embark on this innovate path and launched the Maharashtra Public Private Partnership for Integrated Agricultural Development Project (PPPIAD) with an objective to build integrated value chains for certain crops through PPP and co-investment.

Impact of PPP in Agriculture

The PPP has a positive impact in marketing of farm outputs, reduction in marketing risks and production uncertainties, social mobilization through self-help groups, Farmer Interest

Groups, co-operatives, etc., economic impact on farmers and farm families, women empowerment, etc.

Limitations of PPP models in Agriculture

Resource poor farmers lack capacity to raise their own capital to finance agro-processing infrastructure. The private extension services focus on resourceful areas, resource-endowed farmers and limited to profitable crops and areas.

Private sector seed companies concentrate on hybrids where returns are high and assured. Thus PPP model lacking to benefit of farmers especially for cultivating parental lines of hybrid seed.

Challenges of PPP

Each PPP approach is unique and no two PPP contracts are the same. So it is difficult to standardize a PPP format. The lack of transparency is one of the most discussed problems related to PPP. The long-time taken for creation of PPP arrangement and number of formalities required to follow happen to be another issue in implementation of PPP approach. Undue political favors in many cases are gained by the private party from their public sector counterpart.

Conclusion

PPPs in agriculture have the potential to leverage the resources, expertise, and networks of both public and private sector stakeholders to drive sustainable agricultural development, improve food security, and enhance rural livelihoods. However, effective partnership requires careful planning, transparent governance, and clear alignment of interests and objectives between the parties involved.

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ENHANCING CROP RESILIENCE: VEGETABLE GRAFTING FOR STRESS MANAGEMENT

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Abstract

India is the second largest producer of vegetables next to China. Though the area involved in the vegetable cultivation is large, the yield gap is huge. This is due to the environmental and biotic factors that limits to crops to provide the full potential biomass. Breeding can help to develop biotic and abiotic stress resistant varieties, but, it takes time as the genes involved in the resistance are polygenes. The usage of chemicals can solve the problem to large extent but affects the environmental sustainability. A site specific, environment friendly and quick approach to combat biotic and abiotic stress is Vegetable Grafting. This article will explore on the potentiality of the rootstocks to combat the stresses.

Key words:vegetables, grafting, stresses, rootstocks, mechanism

Introduction

Vegetables are known to be protective food which provides essential minerals and vitamins for our body to function. In India, about 10859 thousand hectares of area is under the vegetable cultivation(https://static.pib.gov.in/), though, it could not meet the full potential yield. The yield gap in the production is due to the biotic stresses like insects, diseases, nematodes and abiotic stresses like the environmental stresses (high temperature, low temperature, drought, flood, salinity). Though the yield gap can be reduced by developing the resistant varieties but the resistant genes for the stresses are polygenes that makes difficult to develop a variety in short period. Another approach can be through the usage of chemicals but it affects the environment.

An environment friendly, faster substitute to breeding and efficient technique to combat the stresses through the mechanism is vegetable grafting. This article provides a wide knowledge about grafting, stresses and how rootstock combat stresses.

Vegetable Grafting

Grafting is a technique in which the scion i.e. the above graft union portion is grafted onto the desirable and potential rootstock which gets successful after their xylem and phloem grow together. The taxonomic affinity determines the successful graft union formation.Grafting is a very old technique in case of fruit crop whereas it is getting momentum from the 1920s in vegetable crop. The first vegetable grafting is done to provide the Fusarium wilt resistance in the watermelon by grafting onto the bottle gourd rootstock in Japan (Kawaide,1985). Cleft grafting, Tongue approach grating, Hole insertion grafting, Splice grafting , Tube grafting and automated grafting are followed in the vegetables.Hole insertion and slant grafting requires hollow hypocotyl plants, specialized grafting tools and experienced labour to graft. Cleft and tongue grafting have higher survival rate when compared to other grafting methods. Grafting is usually done when the plant attains their 2-3 true leaf stage and it is performed under shade during early morning or evening to avoid the transpirational losses. Brimato is a recent grafting technique developed by IIVR, Varanasi to produce two or more vegetables from single plant using double grafting technique. Two scions *viz.,*'Kashi Sandesh' and 'Kashi Aman' grafted onto the rootstock IC 111056**.**This technique is useful in urban and semi urban area where the space is limited for cultivation (Bahadur *et al*., 2023).The most amenable crops for vegetable grafting are solanaceous and cucurbitaceous crops whereas it is diffult to perform grafting in monocots as they lack cambial tissues and have scattered vascular bundle.

Stress and their effects

Stresses are the factors which restrict the photosynthesis and limit the energy conversion to biomass that ultimately reduces the yield (Fig.1.). World Bank reports that climate change will depress crop yields by 20 % or more by 2050. Only 10% of land is not subjected to abiotic stress. The common effects of stress are reduction in photosynthesis, increased transpiration, reduced carbon fixation, changes in stomatal conductance, production of relative oxygen species, hormonal imbalance, damages photosystem altogether retards the growth of plant and ultimately cause reduction in biomass.

Damage from ROS to DNA, lipids, and proteins also results in membrane lipid peroxidation and chlorophyll degradation, which reduce membrane fluidity and selectivity.

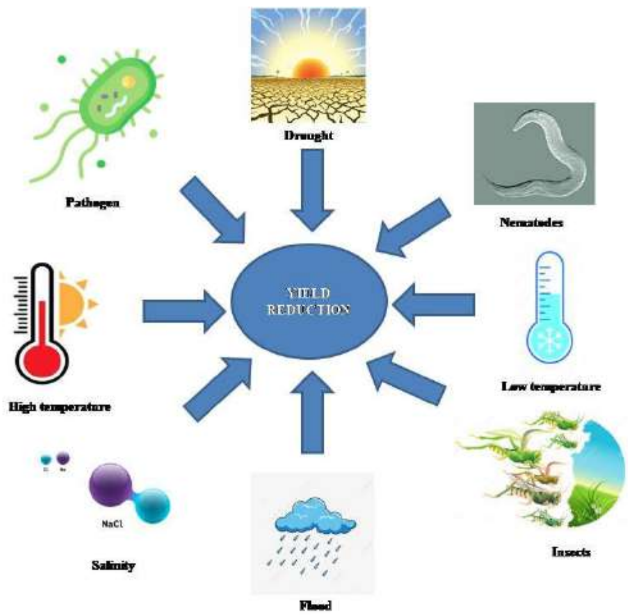

Figure.1. Biotic and abiotic stresses affecting the biomass production

Tolerance mechanism to combat stresses

❖ **Inherent resistant rootstock**

The stress responsive genes in plants, host plant resistance helps in combating stresses. Tomato rootstocks possessing *Mi* gene resistant to root knot nematode infestation

❖ **Robust root structure and enhanced absorption of nutrients**

Strong roots enhance a plant's overall vigor and resilience by more effectively absorbing water and nutrients. Healthy plants are better able to tolerate the stresses caused by pests and diseases.

❖ **Synthesis of Antioxidants**

Stress produces chemicals known as reactive oxygen species (ROS), which are extremely reactive and can harm a variety of cellular constituents, including proteins, lipids, and nucleic acids. Plants have evolved antioxidant defense mechanisms that comprise both enzymatic and non-enzymatic antioxidants to combat the damaging effects of reactive oxygen species (ROS). Specialized enzymes known as enzymatic antioxidants catalyze processes related to detoxification and scavenging the ROS by donating the electrons. Superoxide dismutase, Catalase, Ascorbate Peroxidase, Glutathione Peroxidase are examples of antioxidants.

- **Osmolytes Synthesis**

  Osmolytes are organic compounds that have a role in stress reactions and osmotic control in cells. They are essential in defending cells against a range of environmental challenges, such as oxidative stress brought on by reactive oxygen species (ROS). A few examples of osmolytes are Glutathione, Proline ,Polyols: Sorbitol and Mannitol, Calcium and Vitamin D

- **Hormonal regulation**

  One example is ABA synthesis during drought stress which regulates the stomatal closure and helps in preventing the transpirational loss and maintaining the osmotic balance.

- **Disease tolerance mechanism**

  Most of the soil borne pathogen targets to weaken the vascular tissues especially xylem. The disease tolerance mechanism is through limiting the pathogen colonization by development of tylose, gels in the xylem vessels, phenolic buildup, and callose deposition.

- **Specialized abiotic stress tolerance mechanisms**
  - **High temperature** – Rootstocks tolerates the high temperaturethrough the production of heat shock proteins which acts as molecular chaperons and repairs the proteins that damaged during the heat stress.
  - **Cold temperature** – Rootstocks by optimizing the xylem structure, reduced suberin layer helps in acquiring water and minerals from the roots. In addition to that H^+ ATPase helps in the development of deep root in rootstocks which helps in accessing to aquire water in deep soil layer (Kumar *et al.*, 2018).
  - **Salinity and nutrient toxicity** – Rootstocks through the ion exclusion, selective uptake and compartmentalization of ion in vacuoles prevents salinity and nutrient toxicity.Pumpkin rootstocks have the ability to reduce the build-up of Cl^- and Na^+ in *Cucumis melo* scion leaves. This is achieved by replacing or substituting total K^+ in the leaves with total Na^+ and by excluding or reducing the absorption of Cl^- by the roots.

  - **Drought**-The H^+ ATPase activity and reallocation of photosynthates helps the rootstock the rootstock to develop deep root and to access them when water found deeper which helps in combating stress by maintain osmotic balance.

- **Waterlogging** –Ethylene synthesis, formation of adventitious root and aerenchymatous tissues are the mechanism the plant adapt to tolerate the flooding. Bittermelon grafted onto luffa provide tolerance to flooding by the production of adventitious roots and aerenchymatous tissues.

Constraints in vegetable grafting

- Grafting requires skilled laborers
- Requires favourable environment necessary for graft success and healing.
- Workers who are grafted in greenhouses and growth chambers during the summer months experience heat stress and discomfort
- To get a uniform stem diameter, time management is needed while planting the seeds of the scion and rootstocks.
- Graft incompatibility occurs during the early phases of growth.

Future prospects of vegetable grafting

- Progress in rootstock research will concentrate to find rootstock with higher resistant to pest and diseases, adaptable to wider environmental condition, compatible to make graft with popular varieties.
- Grafting robots which promote automation in grafting which will increase the precision in grafting and reduces the labour requirement.
- The ability to produce uniform, healthy grafted seedlings at a low cost is essential for their widespread adoption, especially in countries with little experience.

Conclusion

Grafting provides a site specific management tool for soil borne diseases and can affect various quality aspects of vegetables as well. Rootstock/scion combinations should be carefully selected for specific and geographic conditions. It fits well into the organic and integrated crop production system as they reduces the need for soil disinfectants and thereby environmental pollution. Grafting technology has a potential in promotion of cultivation in nontraditional and fragile agro-eco system. It is a rapid alternative tool to the relatively slow breeding methodology aimed at increasing biotic and abiotic stress tolerance of fruit vegetables. Since grafting gives increased disease tolerance and vigour to crops, it will be useful in the low input sustainable horticulture of the future.

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REPERCUSSIONS OF NATURAL VEGETATION ON SOIL WEATHERING

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Abstract

Natural vegetation plays a crucial role in shaping soil mineral weathering processes, which in turn influence soil fertility, nutrient availability, and ecosystem dynamics. This paper presents a comprehensive review of the intricate relationship between natural vegetation and soil mineral weathering. First, examine how plant roots, through physical and biochemical mechanisms, interact with soil minerals, leading to mechanical weathering and enhanced mineral surface area for chemical weathering. Roots can penetrate soil crevices, exerting pressure on mineral surfaces, facilitating their breakdown. Furthermore, root exudates, including organic acids, enzymes, and microbial metabolites, can accelerate chemical weathering by altering soil pH and complexing metal ions and explore the impact of different vegetation types (e.g., grasslands, forests, wetlands) on soil mineral weathering. Variations in root morphology, exudate composition, and microbial communities among vegetation types can lead to distinct patterns of soil mineral weathering. The feedback mechanisms between soil mineral weathering and vegetation dynamics, enhanced nutrient availability resulting from mineral weathering can promote plant growth, which in turn influences soil organic matter inputs and root exudation patterns, thereby modulating subsequent weathering processes. Overall, this review highlights the importance of considering the complex interactions between natural vegetation and soil mineral weathering in understanding soil fertility, ecosystem resilience, and the impacts. Further research in this area is essential for developing sustainable land management practices and mitigating the adverse effects of global environmental change.

Introduction

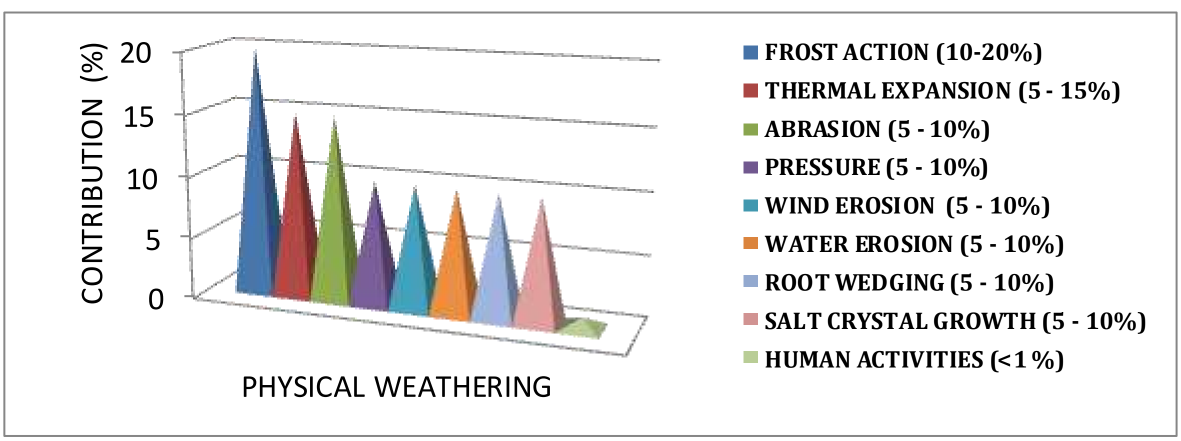
. Soil mineral weathering refers to the process by which minerals within the soil matrix undergo physical, chemical, or biological breakdown, leading to alterations in their composition and structure. This process is influenced by various factors, including climate, topography, and particularly, vegetation cover. The presence and activity of vegetation play a significant role in soil mineral weathering processes. As plants grow, their roots penetrate into the soil, exerting mechanical pressure on mineral surfaces. This physical action can break apart minerals, facilitating further weathering processes. Additionally, plant roots secrete organic acids and other compounds into the soil, which can chemically react with minerals, leading to dissolution and alteration of mineral structures.

Furthermore, the type of vegetation present can have a profound impact on soil mineral weathering. Different plant species release varying types and amounts of organic acids, enzymes, and other substances into the soil through root exudates and litter decomposition. These substances can selectively target certain minerals, accelerating their weathering rates. For instance, trees and other woody vegetation often release more acidic compounds compared to grasses or shrubs, leading to more intense weathering in their vicinity. Moreover, the uptake of nutrients by plants from the soil can indirectly influence mineral weathering. This paper is focus on the specific effects of vegetation on the soil weathering environment.

Different weathering types

- **Physical weathering**

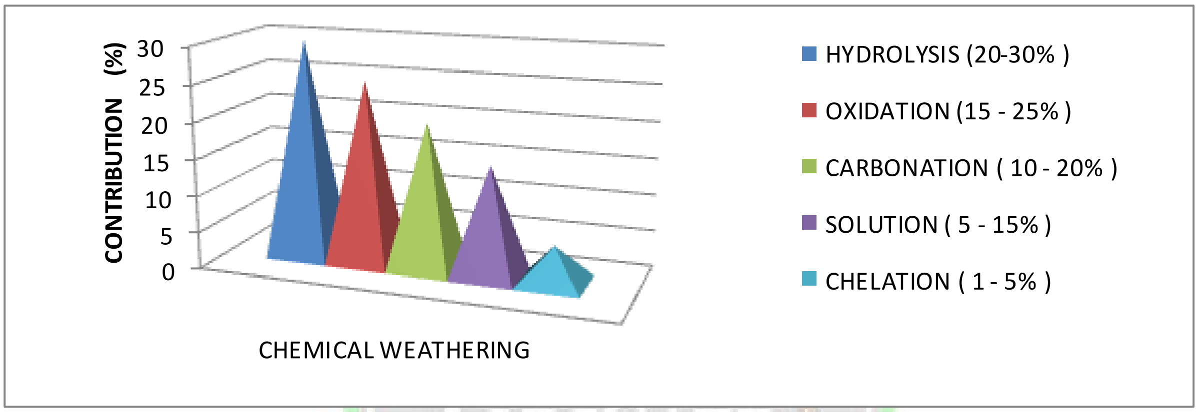
Physical weathering, also known as mechanical weathering, involves the breakdown of soil particles into smaller fragments without altering their chemical composition.



A recent study by Ma *et al.*, (2021) investigated the effects of freeze-thaw cycles on soil aggregate stability and found that repeated freeze-thaw cycles led to the disintegration of soil aggregates, influencing soil structure and erodibility.

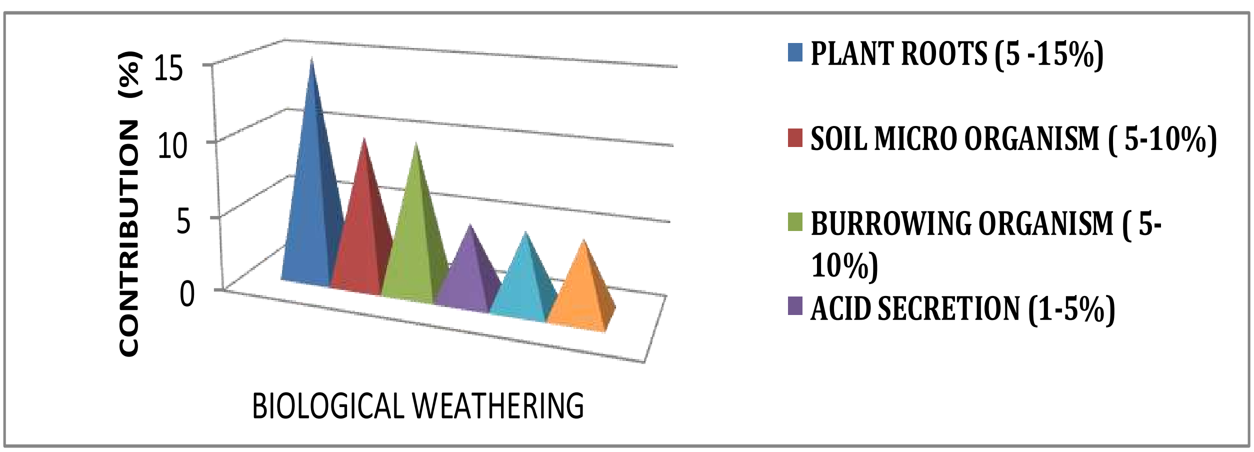
- **Chemical Weathering:**

Chemical weathering involves the alteration of soil minerals through chemical reactions, leading to changes in mineral composition and structure. For example, a study by Li *et al.*, (2020) investigated the role of organic acids in mineral weathering and found that organic acids released by plant roots enhanced the dissolution of certain minerals, affecting soil nutrient availability.



- **Biological Weathering**

Biological weathering involves the actions of living organisms, such as plants, microbes, and burrowing animals, in altering soil properties For instance, a study by Liu *et al.*, (2022) investigated the role of earthworms in soil structure formation and found that earthworm burrowing activities influenced soil aggregation and porosity.



Role of vegetation on soil mineral weathering

Through a variety of mechanisms that impact both chemical and physical weathering, vegetation plays a critical part in the processes involved in soil weathering (Perry, R. S., & Brady, P. V. 2017).

1. Ingress of Roots and Actual Weathering
2. Release of Organic Acids
3. Microbiological Activity

Comparative numerical data table illustrating the influence of vegetation on weathering in different pedology areas

Dominant Vegetation	Pedology Area	Soil Type	pH Range	Organic matter content (%)	Weathering Rate (mm/Yr)	Reference
Desert plants	Arid	Sandy	7.5 – 8.0	0.5 – 1	1 – 4	Belnap *et al.*, 2001
Rainforests	Tropical	Clayey	5.5 – 6.5	3 – 6	3 – 7	Davidson *et al.*, 2007
Deciduous trees	Temperate	Loamy	6.0 – 7.0	2 – 4	2 - 5	Lajtha & Marshall, 1994
Alpine vegetation	Alpine	Rocky	6.5 – 7.5	1 - 2	1 – 3	Hobbie *et al.*, 2000

Impact of tree roots :

Trees can able to modify the soil body hydrology through roots and roots channel. Alter the movement of water from top to bottom. Root zones especially forest soil shows more pedochemically active microsites which enrich water content and nutrients (Pawlik. 2020).

Roots biomechanical process

First roots make space themselves and reorganizing soil particles through the direction of roots resulting tree root mounds which is uniquely observed in large trees results of displacement of soil. The same as in rock called trunk baumsteins or root baumsteins. Movement of rock fragment occurs by growing tree trunk or root (Samonil *et al*. 2018).

Bio-geomorphology effect

The role that plant roots play in influencing geomorphological processes and forming landforms is known as the "bio-geomorphological effects of roots. Roots play a key role in stabilizing slopes and preventing soil erosion by binding soil particles together. According to Stokes et al. (2020), stabilization is necessary to stop landslides and preserve the integrity of riverbanks and hillslopes.

Different types of root exudates

Root Exudates	Chemical Composition	Weathering Effect
Organic acids	✓ Carbonic acid ✓ Oxalic acid ✓ Malic acid ✓ Citric acid	• Chelation of metal ions • Promotion of minerals • Dissolution and • Nutrient releases
Amino Acids	✓ Glutamic acid ✓ Glycine ✓ Alanine	• Promotion of microbial activity • Enhancement of soil organic matter decomposition
Phenolic Compound	✓ Flavonoids ✓ Phenolic acids	• Chelation of metal ions • Involvement in nitrogen cycling
Sugars	✓ Glucose ✓ Fructose ✓ Sucrose	• Stimulation of microbial activity • Promotion of nutrient cycling

Role of microorganism in weathering process

Bacteria	Produce acids that dissolve minerals
	Biofilm formation on rock surfaces
Fungi	Hyphae penetrate rocks, breaking them.
	Decompose organic matter releasing CO_2
Algae	Release organic acids
	Bind soil articles, aiding erosion

Lichens	Secrete acids to dissolve minerals
	Growing into rock crevices, breaking them
Protozoa	Produce enzyme that breakdown minerals
	Create micro environments for weathering
Archaea	Produce methane, affecting soil pH
	Convert sulfur compounds, altering rocks.

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BUCKWHEAT, A PROMISING PSEUDOCEREAL

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Introduction

Buckwheat is botanically called *Fagopyrum esculentum* is a Pseudocereal, Growing buckwheat is popular because of its triangular, black or gray seeds. Along with being a pharmaceutical plant that yields rutin, it can also be grown as a companion crop, a cover crop, a source of buckwheat honey, and a green manure crop. Not a true cereal, buckwheat is a member of the Polygonaceae family. But the buckwheat grain is a dry fruit, just like cereals like wheat, corn, and rice, which are members of the grass family.

Orgin and Distribution:

It is thought that buckwheat originated in central and northeastern Asia, and it was most likely grown in China in the fifth and sixth century. In the fourteenth and fifteenth centuries, it was brought to Europe via Turkey and Russia; in the seventeenth century, it reached North America. The amount of buckwheat produced worldwide peaked in the early nineteenth century and has since decreased. It has averaged almost 2.7 million tonnes over the last five years (1995–1999), with China and the former Soviet Union contributing 58 and 34% of the world's production, respectively. Brazil, Poland, the United States, Japan, Canada, France, Bhutan, the Republic of Korea, and South Africa are further significant producers.

Types and Cultivars:

While there are at least 15 species of buckwheat in the genus *Fagopyrum*, only two are used for food or feed. The other species, wild buckwheat (*F. cymosum*), is mostly found as a tetraploid and is occasionally used as a green vegetable or as fodder for cattle. The common buckwheat (*F. esculentum*), tartary buckwheat (*F. tataricum*), and perennial buckwheat (*F. cymosum*) are the three main species of buckwheat. Another name for common buckwheat is *F. saggitatum*, and *F. kashmirianum* is the name for a type of tartary buckwheat. All agree, however, that the diploid variety of perennial buckwheat is the ancestral form of both tartary and common buckwheat. In the Himalaya region of India and China, eastern Canada, and occasionally mountainous eastern United States, tartary buckwheat is grown. Because of its limited resistance to cold, it is cultivated at higher elevations where there is a higher chance of frost damage. The seeds have a greenish tint, and the goods derived from them have a slightly bitter flavor. It is mostly utilized as feed, or in a blend of buckwheat and wheat flour, and is frequently utilized as a rutin source.

Plant and Seed Morphology:

The tall, herbaceous, broad-leaved buckwheat plant can reach a height of 0.70 to 1.5 meters. It can achieve full maturity in less than ninety days and contains several branches in addition to its primary stem. With the exception of the nodes, the stem is often hollow, succulent, and grooved. The stems and branches have a green to red tint before they mature, and they turn brown after that. The plant has a shallow taproot that lateral roots branch off of. Its roots make up only 3-4% of the plant's dry weight, which is a smaller amount than those of cereals.

Flowering:

Buckwheat flowers in an unpredictable manner. Common buckwheat blossoms are flawless yet lacking something. Although they lack petals, the calyx is made up of five sepals that resemble petals and are often white but can also be pink or red. Dense clusters of flowers are found at the tips of branches or on short pedicels that emerge from the leaf axils. Common buckwheat has plants bearing one of two types of flowers. The pin-type flower has long styles, or female parts, and short stamens, or male parts, and the thrum-type has long styles and short pistils. The pistil consists of a one-celled superior ovary and a three-part style with knoblike stigmas and is surrounded by eight stamens. . At the base of the ovary are glands that secrete nectar. Because self-incompatibility prevents self-fertilization, common buckwheat plants are typically sterile. In most cases, cross-pollination between pin and thrum flowers is required for seed development. Leaf-cutter bees and honey bees are efficient pollinators. Both seed set and seed yield are increased. The triangular, dry fruit 0011 (achene) of buckwheat, measuring 4–9 mm in length, is composed of an embryo, spermoderm, endosperm, and hull.Small seeds typically have convex sides, but large seeds typically have concave sides. The hull might have a solid or mottled appearance and be shiny, gray, brown, or black. It might have lateral furrows and be smooth or rough. The hulls make up 17–26% (or 30–35%) of the weight of the kernels in tartary buckwheat. Compared to tetraploids, diploid cultivars typically have a thinner hull.

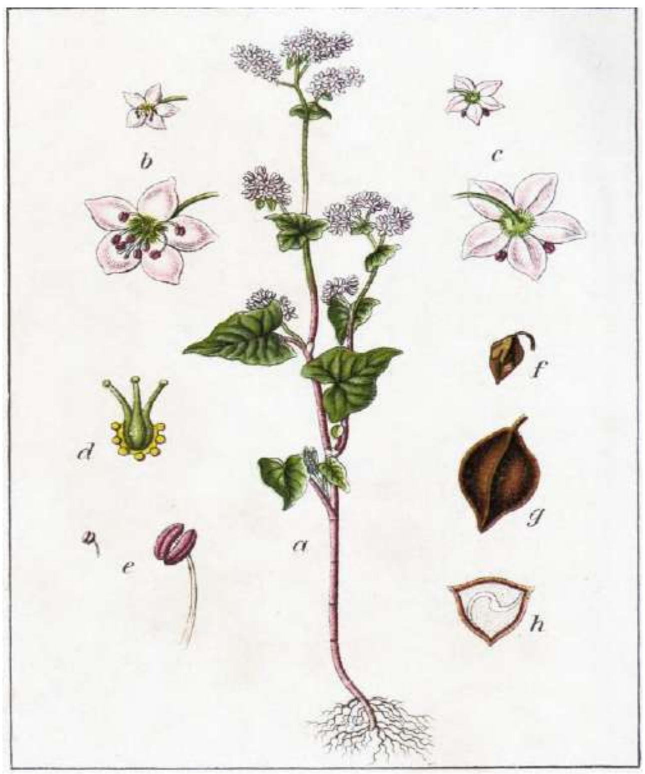

Fig. 1. Buckwheat- *Fagopyrum esculentum*

Structure of Kernel:

The buckwheat kernel's hull, spermoderm, endosperm, and embryo are all made up of many layers, as shown by scanning electron microscopy. The hull's epicarp, fiber layers, parenchyma cells, and endocarp are arranged from outside to inside. The spongy parenchyma, the inner epidermis, and the outer epidermis make up the spermoderm. The endosperm is made up of a subaleurone endosperm that contains starch granules encased in a proteinaceous matrix and an aleurone layer that is 10–15 micrometers thick. The two cotyledons of the embryo protrude through the starchy endosperm. Under the kernel surface, the terminal segments of cotyledons are frequently parallel.

Table 1. Nutrient composition of Buckwheat grain

Moisture (g per 100g)	16.2
Protein3 (g per 100 g)	14.2
Crude fiber (g per 100g)	1.57
Ash (g per 100 g)	1.85
Lipidsb (g per 100 g)	2.6
Carbohydratesc (g per 100 g)	79.8
K (mg per 100g)	440
P (mg per 100g)	359
Mg (mg per 100 g)	214
Ca (mg per 100 g)	18
Fe (mg per 100 g)	2.5
Zn (mg per 100 g)	2.3
Mn (mg per 100 g)	1.0
Cu (mg per 100 g)	0.03

Functional value:

Because of the presence of rutin, common buckwheat and its constituents are considered functional foods in Japan. It is well known that rutin makes blood vessels more elastic, which keeps the arteries from hardening. Chinese medicine claims that the leaf and stem of tartary buckwheat can be used as an adaptogen, heal ulcers, help with hemostasis and hypertension, and enhance vision and hearing. Tartaric buckwheat eating is said to help with gastrointestinal issues in Nepal. Buckwheat consumption has been linked to the management and prevention of hypercholesterolemia. The protein in common buckwheat is responsible for this effect; it functions similarly to dietary fiber and has a greater hypocholesterolemic action than soy protein isolate. Because buckwheat protein extract is poorly digestible, it lowers blood estrogen levels, which delays the development of breast cancer in rats. It also causes a reduction in body fat. Because bioactive peptides from buckwheat pollen stimulate lymphocytes' immune systems, they may function as an immunomodulator to boost immunity and treat cancer. It has been suggested that buckwheat flour has physiological activity in the management of diabetes, hyperglycemia, hyperlipemia, and cardiovascular disease. Clinical results show that 75 diabetic individuals receiving tartary buckwheat biscuits experienced a drop in blood sugar. Fagopyritols are a class of phytochemicals found in buckwheat bran that function as an insulin mediator and may be useful pharmacologically in the management of noninsulin-dependent diabetic mellitus (NIDDM). When combined with vitamin C, rutin from buckwheat shields the endothelium and stops ascorbic acid from oxidizing. As a result, rutin and fagopyritols together can significantly aid in the prevention of diabetes.

Products:

Buckwheat is useful in many ways. It is utilized to produce alcoholic beverages, with the liquor made from tartary buckwheat having purported health benefits. It's utilized to make vinegar in China. Many nations also use common buckwheat as a source of nectar for making honey. As a green manure crop, buckwheat can help revitalize low-productivity soil. Because the plant germinates quickly and forms a dense canopy that keeps broad-leaved weeds under control, it has been employed as a smother crop. It serves as a cover crop and food for deer, wild turkeys, and other birds, among other species. Buckwheat flour typically has a dark color because it contains hull particles. It is mostly sold as prepackaged mixes in North America, where it is mostly used to make buckwheat pancakes. Buckwheat flour is typically combined with flours such as wheat, corn, rice, oat, or soybeans, along with a leavening agent, in these mixtures. Additionally, buckwheat is combined with rice, corn, or wheat to make ready-to-eat breakfast items, porridge, bread, and pasta products. It is also combined with vegetables and spices to make kasha and soup mixes.

Buckwheat flour is mainly used in Japan to make Teuchi Soba, or hand-made buckwheat noodles, and soba or sobakiri, or buckwheat noodles. These goods are made at home or in soba shops using a blend of wheat and buckwheat flours. Because of its availability and binding qualities, wheat flour is employed. Soba is either mechanically or manually manufactured.

Both techniques include combining wheat and buckwheat flours with water to create a stiff dough that is either passed between sheeting rolls and sliced into long strips or kneaded and rolled into a thin sheet (1.4 mm) with a rolling pin. The product can be dried, sold fresh, or cooked right away.The majority of buckwheat in Europe is ground into groats, which are then eaten with fresh or sour milk, porridge, cabbage rolls, and meat products (particularly hamburgers). Many dumplings are filled with buckwheat groats, cottage cheese, sugar, peppermint, and eggs. Buckwheat flour is combined with yeast, wheat flour, or rye flour to make fried specialized items such biscuits, bread, and other confections. Western Europe is producing and selling an extruded, high-nutrient breakfast product made of corn and buckwheat. This food has 8% soluble fiber and over 14% protein. Poland and the former USSR have also created comparable items.

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PLANT DISEASE EPIDEMIOLOGY

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Introduction

From the time that the first farmers began to cultivate plants, people have been concerned with reducing the crop losses caused by plant diseases. Through the evolution of our crop production technologies over the last ten thousand years, the principles of plant disease management have been woven into the fabric of our civilization. The decisions of when, where, and what to plant and the development of specific cultural practices have been based on countless generations of trial and error. Without a doubt, the successful farming methods depended upon being able to suppress the development of plant pathogens, even if the farmer had no particular awareness of the underlying biological mechanisms that led to her or his success. Everywhere in the world, either directly or indirectly, our attempts to manage plant disease have determined what we eat and where we have settled.

This unit describes how plant disease develops through time, and it introduces mathematical models of plant disease epidemics. Examples from the published literature show how these models can be used to help make management decisions.

Plant Disease Epidemiology?

Plant disease epidemiology? How can there be an **epidemic** on plants? (Gr. *epi*, on; *demos*, people) Well, strictly speaking, we should call it an **epiphytotic**, but the term "epidemic" has become so widely used in reference to plant disease and so entrenched in the phytopathological literature that we are forced to give in and leave "epiphytotic" to the etymological purists. So if we accept "epidemic" to apply to plant populations, then "epidemiology" refers to the study of the development of disease in those populations. However, these terms still are technically imprecise and sometimes confusing because of their common usage. "Epidemic" is often used in such expressions as "epidemic proportions" to mean a high level of disease. "Epidemic" also is commonly used to denote a sudden and rapid or a widespread development of disease, implying that if development is slow or it is spatially limited there is no epidemic.

In this text we will use "epidemic" to denote the dynamics of disease, that is, the change in the amount of disease with time. By "amount" of disease we mean either incidence (the number of plants or plant parts affected), severity (the amount of tissue affected), or a combination of both. By this definition there can be fast epidemics or slow epidemics, and there can even be "negative" epidemics, in which there is a decrease in the amount of disease with time. For example, if we are using the proportion of leaves infected as a measure of disease incidence, and during a dry spell we get new, healthy leaves forming while the infected ones drop off, we could get a negative change in the amount of disease.

Associated with the change in the amount of plant disease with time is a change in the spatial distribution of lesions or of infected plants. A good working definition of epidemic, therefore, is a change in plant disease in time and space.

The term **endemic** is sometimes used (erroneously) to mean the opposite of "epidemic", that is, to denote constant disease, because in areas where the pathogen and its host have coevolved over long periods of time, they often have reached an equilibrium where there is little change in the amount of disease with time. In the strict sense "endemic" means native to a particular area, and therefore we can have epidemics of endemic diseases.

Disease Progress

Disease on plants usually starts out at a low level, a small number of plants affected and a small amount of plant tissue affected, and it becomes of concern to us only when its incidence and severity increases with time. When we look at some examples of plant disease epidemics from the published literature, we not only notice that the incidence or severity starts near zero and then increases dramatically, but we also can discern some distinct patterns of development with time. For example, in Phytophthora blight of pepper seedlings (*Phytophthora capsici*) and Fusarium kernel rot (*Fusarium moniliforme, currently F. verticilloides*) of maize, disease progress is roughly linear (allowing for some minor deviations that we can consider random error). On the other hand, in bean rust (*Uromyces phaseoli*) and grey leaf spot of corn (*Cercospora zeae-maydis*), there is a definite upward curve; that is, disease increases at an increasing rate, a curve we could call exponential.

Obviously plant disease cannot continue to increase forever, and as the level of disease approaches 100%, the disease progress curve gradually flattens out. For example, in epidemics such as the infection of beans by *Sclerotium rolfsii* or the infection of tobacco by *Phytophthora nicotianae*, disease progress starts out looking linear but slows down as it approaches a maximum.

Likewise, the disease progress curves of *Puccinia graminis* subsp. *graminicola* on ryegrass and *Pyrenophora teres* f. sp. *teres* on barley appear exponential at first, but as time goes on and the incidence and severity of disease approach 100%, the rate of disease progress gradually slows to zero, giving both curves a somewhat sigmoid shape ("S" shape).
o be sure, not all examples of disease progress can be as neatly categorized as these, but in general plant disease epidemics tend to be either roughly linear or exponential in the early stages, and they tend to level off as they approach some limit.

The impact of plant disease and the losses that it causes are a function of disease progress. To reduce this impact, we need not eliminate the disease, we merely need to keep disease development below an acceptable level. That means that the progress of disease and the factors that influence disease progress must be understood in quantitative terms. We have to know what kinds of diseases lead to linear disease progress and what factors affect the slope of the line (the rate of disease progress). Likewise, we have to know what kinds of diseases tend to produce exponential disease progress curves and how we can reduce both the starting level of disease and the rate of epidemic development. Finally, we have to know why epidemics sometimes level off and what imposes limits to their development.

The Cyclical Nature of Plant Disease

Plant disease epidemics are cyclical phenomena, that is, they consist of repeated cycles of pathogen development in relation to the host and the environment. The inoculum, which might consist of fungal spores, bacterial cells, nematodes, viruses within an aphid vector, or some other propagules of a pathogen, gains entry into and establishment within the host tissues through the process of infection. The pathogen develops within the host and eventually begins to produce new inoculum, which, in turn, can be dispersed to new susceptible sites to initiate new infections. Pathogens that produce only one cycle of development (one infection cycle) per crop cycle are called **monocyclic**, while pathogens that produce more than one infection cycle per crop cycle are called **polycyclic**. Generally in temperate climates there is only one crop cycle per year, so the terms "monocyclic" and "polycyclic" are based on the number of cycles per year. In tropical or subtropical climates, however, there can be more than one crop cycle per year, and it is important to remember that "monocyclic" and "polycyclic" are based on a single crop cycle. These same terms are used to describe the epidemics as well as the pathogens, so we often speak of a "monocyclic epidemic" or a "polycyclic epidemic".

For some diseases it is important to consider an epidemic over a period of many growing seasons. This is particularly true for perennial plants (forages, pastures, lawns, orchards, forests, etc.) or for annual crops that are grown in monoculture year after year. In these situations the inoculum produced in one growing season carries over to the next, and there could actually be a buildup of inoculum over a period of years. In the tropics there may not be clear-cut breaks between growing seasons such as we find in the temperate zones, and epidemics can be virtually continuous over periods of many years on such crops as bananas, coffee, and rubber trees. We refer to these epidemics as **polyetic** epidemics, regardless of whether the pathogen is monocyclic or polycyclic within each season.

The Dutch elm disease is an example of a monocyclic pathogen giving rise to a polyetic epidemic. Note that while there is only one cycle of infection each year and disease progress within each year is roughly linear, the incidence of infected trees increases at an increasing rate from year to year. Apple powdery mildew is an example of a polyetic epidemic caused by a polycyclic pathogen. Note how the incidence of infection at the start of each year tends to increase exponentially.Sigatoka leaf spot on bananas decreases somewhat during the dry season but otherwise produces more or less continuously repeated cycles of infection. The host, in this case, consists of a population of plants of different ages developing continuously over a long period of time.

If we analyze the disease cycles of the epidemics for which we have plotted disease progress, we see that the epidemics that progress roughly linearly or are linear at the start tend to be monocyclic epidemics. On the other hand, the diseases that increase at an increasing rate during the early part of the epidemic tend to be polycyclic epidemics.

Monocyclic Epidemics

In general, there are three types of plant diseases that tend to produce only one infection cycle per host cycle (1) postharvest diseases, (2) diseases caused by soil-borne plant pathogens, and (3) rusts without a urediniospore stage.

Postharvest Diseases

Not all postharvest diseases produce monocyclic epidemics, but in many cases the infections that result in storage rots have either already occurred before harvest or occur during the harvest and postharvest handling before the product goes into storage. The rot progresses during storage, and new inoculum may be continuously produced, but unless the stored product is handled again to disperse the inoculum and create new infection sites by making small wounds, there are no new infection cycles. Note that the pathogen is not inherently monocyclic but is constrained by the environment to produce only a single cycle of infection. In other environments, these same pathogens might produce polycyclic epidemics.

Disease Caused by Soilborne Plant Pathogens

Many of the root rots, vascular wilts, and other diseases caused by soilborne pathogens also produce only one infection cycle per crop cycle. The inoculum generally is some kind of survival structure resistant to desiccation or freezing, such as sclerotia, chlamydospores, or oospores in the soil or mycelium in crop residues. This inoculum is dispersed in the soil by plowing and fitting the land and turning under the crop residues. As the roots of the newly planted crop grow through the soil, they encounter the propagules of the pathogen embedded in the soil matrix and become infected. The epidemic progresses as new infections occur, but since any new inoculum that is produced is not dispersed until the soil is again cultivated, there is only one complete infection cycle per cropping cycle. To be sure, not all soilborne plant pathogens produce monocyclic epidemics, and one must be very careful to understand the life cycle of each pathogen before drawing conclusions about its epidemiology.

Demicyclic rust

Some rusts produce no urediniospore stage (repeating stage) on a single host, and the inoculum produced on one host species generally must infect a different host species. This alternation of hosts appears to have evolved in adaptation to the annual growth cycles of the hosts, and we see one infection cycle on each host per year. An example is the cedar-apple rust, where all the inoculum that infects apples comes from galls on red cedars (junipers), and all the inoculum that infects red cedars comes from apple leaves and fruit. The epidemic on apples occurs during a four- to six-week period of basidiospore production in the spring. A second monocyclic epidemic on red cedars occurs during a brief period of aeciospore production in late summer.

Polycyclic Epidemics

In order for an epidemic to be considered polycyclic, there must be repeated complete infection cycles, that is, infection followed by pathogen development, new inoculum production, dispersal to new susceptible sites, and new infections, all within a single crop cycle. A good example is potato late blight, where a single cycle of infection, lesion development, sporulation, sporangium dispersal, and new infection can occur in as little as five days, and many overlapping cycles occur simultaneously during periods of favorable weather. Each cycle can produce more than a ten-fold increase in numbers of sporangia landing on susceptible sites, and an explosive epidemic results. Cereal rusts behave similarly; a single urediniospore can infect to produce a pustule from which hundreds of new urediniospores can be released to infect and produce hundreds of new pustules repeatedly throughout the season. Most plant diseases caused by bacteria are polycyclic, and many plant viruses, with the aid of their insect vectors, also can produce repeated cycles of infection in one season.

Combinations of Monocyclic and Polycyclic Epidemics

Not every plant disease epidemic is clearly either monocyclic or polycyclic. Epidemics produced by fungi with two spore stages can have elements of both, sometimes in distinct phases, and sometimes occurring simultaneously. For example, the fungus *Venturia inaequalis*, causal agent of apple scab, produces ascospores on the dead, infected leaves that have overwintered from the previous season. These ascospores are released over a period of six to eight weeks in the spring and infect the newly expanding apple leaves. Since no new ascospores are produced until the following spring, this component of the epidemic might be considered monocyclic. However, each leaf lesion within about ten days produces a second type of spores, conidia, that also can infect newly expanding leaves. Thus, for the early part of the season, a polycyclic epidemic is superimposed on a monocyclic epidemic. Since lesions produced by conidia cannot be distinguished from those produced by ascospores, the net effect appears to be a rapidly growing polycyclic epidemic.

An epidemic of tan spot on wheat, caused by *Pyrenophora tritici-repentis*, also comprises both polycyclic and monocyclic elements. The initial inoculum occurs on infected seed, and the epidemic starts as these seeds germinate to yield seedlings bearing leaf lesions. Conidia are disseminated by wind and splashing rain in repeated cycles of leaf infection throughout the period of crop development (the polycyclic phase). By the time flowering begins, the inoculum for the second phase of the epidemic has built up on the upper leaves of the plant, principally the flag leaf. The flowers and developing grains are susceptible for a relatively brief period to infection by the inoculum extant at the time of flowering, and the lesions on the glumes of the developing grains do not produce inoculum capable of infecting more grains. Seed infection, therefore, is a monocyclic phenomenon. It is these infected seeds that provide a major means of carryover of this pathogen from one crop to the next and the initial inoculum for the new crop.

Plant Disease Management Strategies

Since the beginning of agriculture, generations of farmers have been evolving practices for combating the various plagues suffered by our crops. Following our discovery of the causes of plant diseases in the early nineteenth century, our growing understanding of the interactions of pathogen and host has enabled us to develop a wide array of measures for the control of specific plant diseases.

From this accumulated knowledge base, we can distill some general principles of plant disease control that can help us address the management of new problems on whatever crop in any environment. One such set of principles, first articulated by H. H. Whetzel in 1929 and modified somewhat by various authors over the years, has been widely adopted and taught to generations of plant pathology students around the world.

Traditional Principles of Plant Disease Control

1. **Avoidance**—prevent disease by selecting a time of the year or a site where there is no inoculum or where the environment is not favorable for infection.
2. **Exclusion**—prevent the introduction of inoculum.
3. **Eradication**—eliminate, destroy, or inactivate the inoculum.
4. **Protection**—prevent infection by means of a toxicant or some other barrier to infection.
5. **Resistance**—utilize cultivars that are resistant to or tolerant of infection.
6. **Therapy**—cure plants that are already infected.

While these principles are as valid today as they were in 1929, in the context of modern concepts of plant disease management, they have some critical shortcomings. First of all, these principles are stated in absolute terms (e.g., "exclude", "prevent", and "eliminate") that imply a goal of zero disease. Plant disease "control" in this sense is not practical, and in most cases is not even possible. Indeed, we need not eliminate a disease; we merely need to reduce its progress and keep disease development below an acceptable level. Instead of plant disease **control**, we need to think in terms of plant disease **management**.

A second shortcoming is that the traditional principles of plant disease control do not take into consideration the dynamics of plant disease, that is, the changes in the incidence and severity of disease in time and space. (See: Disease Progress.) Furthermore, considering that different diseases differ in their dynamics, they do not indicate the relative effectiveness of the various tactics for the control of a particular disease. They also fail to show how the different disease control measures interact in their effects on disease dynamics. We need some means of assessing **quantitatively** the effects of various control measures, singly and in combination, on the progress of disease.

Finally, the traditional principles of plant disease control tend to emphasize tactics without fitting them into an adequate overall strategy.

Does this mean that we should abandon the traditional principles? Of course not! We merely have to fit them into an appropriate overall strategy based on epidemiological principles.

Strategies* versus*Tactics

Ask a handful of pest management experts to name the major plant disease control strategies, and you are sure to find disagreement. The problem is generally one of semantics rather than of fundamental disagreement over the important means of disease control. The dictionary definitions for the two terms are similar, but generally speaking, an overall plan for reaching a particular objective is called a **strategy,** while the specific means for implementing a given strategy are called **tactics**. Like the goals and objectives that they are intended to achieve, strategies and tactics tend to occur in hierarchies. What is a "strategy" at one level of focus could be called a "tactic" at another level of focus.

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GUINEA MILLET- AN UNDERUTILIZED PSEUDOCEREAL

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INTRODUCTION:

Guinea millet, scientifically known as *Brachiaria deflexa* or *Urochloa deflexa*, is a type of millet that is cultivated primarily in West Africa. It's a cereal crop valued for its drought tolerance and ability to grow in poor soil conditions. Guinea millet is a staple food in some regions and is used for various purposes, including human consumption, animal feed, and thatching material for roofs. The grains are small and round, and the plant is known for its resilience in challenging agricultural environment. ***Brachiaria deflexa*** is commonly known by several other names, including "Australian bluestem" and "weeping signal grass." These alternative names are often used regionally or in different contexts. It is known for its adaptability to diverse environmental conditions, making it a popular choice in tropical and subtropical regions.

BOTANY OF GUINEA MILLET:

Common name	Guinea millet, Australian bluestem, weeping signal grass
Scientific name	*Brachiaria deflexa*, or*Urochloa deflexa*
Family	Poaceae
Chromosome number	2n=36
Name of the inflorescence	panicle
Leaves	Linear, with a prominent midrib, and they may have a

	weeping appearance.
Height	1-2 Meters
Crop duration	90-130 days

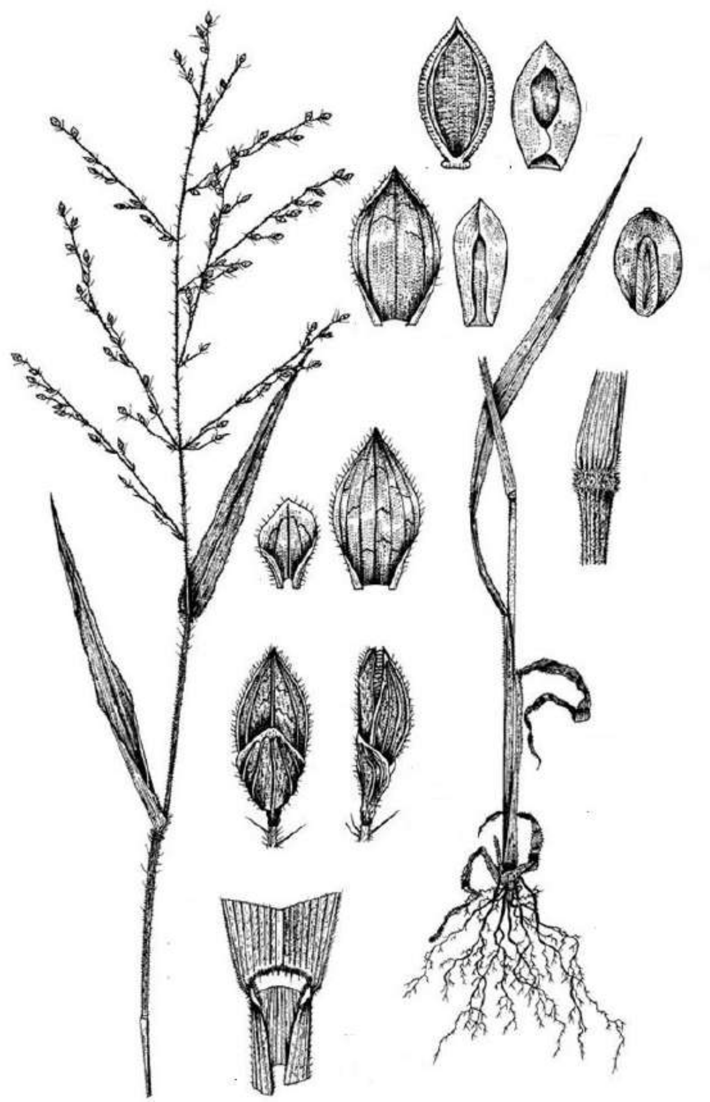

Fig. 1. ***Urochloa deflexa*–Guinea millet**

DISTRIBUTION OF *Bracharia deflexa:*

Brachiaria deflexa, also known as Guinea millet or weeping signal grass, is native to Africa but has been widely introduced and cultivated in various tropical and subtropical regions around the world. Its distribution is influenced by its adaptability to diverse environmental conditions. This grass species is commonly found in regions with warm temperatures and is well-suited to areas with tropical and subtropical climates.

The distribution of *Brachiaria deflexa* may include countries in Africa, Asia, the Americas, and Australia, where it is often utilized for pasture, forage, and erosion control purposes. The specific areas of cultivation and prevalence may vary based on local agricultural practices and ecological factors.

CULTIVATION PRACTICES:

Guinea millet is typically grown in warm climates with well-drained sandy or loamy soils. Here are some key cultivation practices:

Climate and Soil:

Guinea millet thrives in warm temperatures and is well-suited to regions with a tropical or subtropical climate.

It prefers well-drained soils, and sandy or loamy soils are generally suitable.

Planting:

Planting is usually done at the onset of the rainy season.Seeds are sown directly in the field, and the planting density depends on local practices and soil fertility.

Spacing:

Proper spacing between rows and plants is essential to ensure optimal growth and yield.

Watering:

While Guinea millet is known for its drought tolerance, it still benefits from adequate moisture during its growth stages.

Fertilization:

Fertilizer requirements may vary based on soil conditions. Typically, organic matter or balanced fertilizers can be applied before planting.

Weeding:

Regular weeding is crucial to prevent competition for nutrients and sunlight. Hand weeding or other appropriate methods are employed.

Pest and Disease Control:

Monitoring for pests and diseases is important. Common pests include birds and insects, while diseases like rust and smut can affect the crop.

Harvesting:

Guinea millet is harvested when the grains have reached maturity. This is typically when the plant has dried, and the grains have hardened.

Post-Harvest Handling:

After harvesting, the grains are separated from the rest of the plant. They may be stored in a cool, dry place to prevent spoilage.

Crop Rotation:

Implementing crop rotation practices helps maintain soil fertility and reduce the risk of diseases.Adapting these practices to local conditions and considering variations in climate and soil types can contribute to successful Guinea millet cultivation.

USES:

- While *Brachiaria deflexa* (Guinea millet) is primarily known as a forage grass, it is not commonly recognized for significant medicinal uses.
- Its main applications are in agriculture, particularly as fodder for livestock due to its nutritional content and adaptability to different climates.
- Guinea millet, is a warm-season grass commonly used for forage and pasture purposes.
- Guinea millet is valued for its high nutritional content and ability to thrive in a variety of soils.
- It's often utilized as fodder for livestock due to its palatability and resilience.
- Additionally, this grass species plays a role in soil conservation and erosion control
- *Brachiaria deflexa*, commonly known as Guinea millet or weeping signal grass, is primarily recognized for its agricultural applications, particularly as forage for livestock.
- While it is not commonly associated with direct human health benefits, its cultivation and use in animal husbandry contribute to indirect health benefits. Here are some points to consider:
- **Livestock Nutrition:** Guinea millet is valued for its nutritional content, providing a balanced mix of proteins, carbohydrates, and minerals. When included in animal diets, it can enhance the overall health and productivity of livestock.
- **Sustainable Agriculture:** The cultivation of Brachiariadeflexa can contribute to sustainable agriculture practices. It is known for its adaptability to different climates and soil types, which can aid in soil conservation and erosion control.

- **Livestock Products:** By improving the nutrition of livestock, products such as meat and milk derived from animals that consume Brachiariadeflexa may indirectly contribute to human nutrition.
- While it may not have direct health benefits for humans, the cultivation and use of *Brachiaria deflexa* play a crucial role in supporting livestock health and sustainable agricultural practices.

NUTRITIONAL VALUE OF *Brachiaria deflexa:*

- Specific nutritional values *Brachiaria deflexa* may vary, but in general, this grass is valued for its nutritional content, especially in the context of forage for livestock.
- It typically provides a good balance of essential nutrients for grazing animals.
- Commonly, forage grasses like *Urochloa deflexa* contain proteins, carbohydrates, fiber, and various minerals.
- The nutritional value can depend on factors such as soil conditions, climate, and growth stage when harvested. For precise information on the nutritional composition of *Urochloa deflexa*, it's recommended to consult scientific literature, agricultural extension services, or research institutions that focus on forage and pasture management

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WILD GENETIC RESOURCES IN SESAMUM

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Introduction

Sesamum is commonly called as Ellu or Till belongs to Pedaliaceae, in agronomic classification its belongs to oil seed crop. The chromosome number 2n= 26 It is referred as 'queen of oilseeds' and a small family of 17 genera and 80 species of annual and perennial herbs that occur in the Old World tropics and subtropics. Other genera that are considered to be related to Sesamum are Ceratotheca, Martyniaceae, Anthadenia, and Volkameria . Sesame contains about 35–60% oil and 19–30% protein and Sesame oil is highly stable compared with the other edible oils, mainly due to the presence of antioxidants including sesamin, sesaminol, sesamol, sesamolinol, and squalene contents in the seed.

History

Sesame (*Sesamum indicum* L.) is one of the oldest oilseed crops known to mankind and its cultivation dates back to 3050–3500 BC. It is grown in tropical and subtropical regions of the world. Evidence indicates that **Ethiopia is sesame's center of origin**. There is considerable dispute regarding the Afghan/Persian region as the place of origin, with secondary centers in India and China, as sesame was an important crop in the Persian region during 2130–2000 BC. Sesame was grown during the ancient Harappan, Mesopotamian, and Anatolian eras for its edible seed and its oil. Ironically, it is considered as an 'orphan crop' also. Sesame is resistant to drought, it is a low cost crop and is therefore known as one of the best alternative specialty crops.

Economic Importance

- Sesame is cultivated on a world wide basis for its seeds, oil and protein. Seeds are used either as a whole or decorticated in sweets or confectioneries, in bakery products and milled to get oily paste. Sesame seeds also find place in several rituals in countries such as India, Nepal etc. interestingly, sesame seed is a reservoir of nutritional components with numerous beneficial effects and promotes human health. The bioactive components present in the seed include vital minerals, vitamins, phytosterols, polyunsaturated fatty acids,tocopherols and a unique class of antioxidant compounds, lignans that impart its antioxidative potential. The seed meal is also high in protein (35–50 %) and contains significant amount of amino acids such as tryptophan and methionine.
- Sesame oil is used in cooking, in preparation of salads and finds use in the production of margarine, soaps, pharmaceuticals, paints and lubricants. **The seed oil content ranges from 32.5 to 58.8 %, which is generally greater in white than black seeds** . In majority, sesame oil consists of triacylglycerols (95 %), diacylglycerols (2.6 %), A high proportion of polyunsaturated fats in sesame oil mainly consist of linoleic (35–50 %), oleic (35–50 %), stearic (3.5–16 %) and palmitic (7–12 %) acids Linolenic acid is also present but only up to 1 % of the total fatty acids.
- Sesame oil used in combination with soybean oil enhances the nutritive value of the lipids and increases vitamin E activity and in combination with canola or mustard oil has been recommended for healthy diets. Sesame oil has several health benefits like growth arresting and apoptosis prevention properties in cancer cells; useful in the treatment of several chronic diseases, including hepatitis, diabetes and migraine, alleviating depression and fatigue; and has antibacterial and antiviral properties for common skin pathogens.
- In addition, sesame oil maintains good cholesterol and lowers bad cholesterol and acts as a UV-protectant. The beneficial properties of sesame oil are owing to three major constituents namely lignans, tocopherols and phytosterols. In addition, investigations on use of sesame oil as a source for biodiesel have resulted in a product with fuel properties in parity with mineral diesel but with superior environmental performance

Wild Relatives of Sesame:

In wild Sesamum species. Palmitic, stearic, oleic , and linolei acids were the principal fatty acids in all the wild species and cultivated Sesamum. Wild Sesamum species exhibited a wide range of variation in palmitic and stearic acid contents. Stearic acid content in all the wild species was significantly higher than in the cultivated sesame. Lower oleic acid and higher linoleic acid contents were apparent in the wild species of sesame vary in their habitat, morphological features and ploidylevel, latter of which is represented by three chromosome groups 26, 32, 64 . Wild relatives have also been delineated into gene pools based on available hybridization studies for limited number of taxa.

S. malabarcium.

S. indicum

S. alatum

S.*mulayinum*

S. *prostratum*

S.lacinatum

S.*radiatum*

Fig 1. Wild Relatives of Sesame

The crop plant *S. indicum* and its progenitor S. indicum subsp. *malabarcium.*Two species namely, *S. alatum* and S. *prostratum* have been placed under gene pool-2 due to barriers in hybridization with *S. indicum*. Although, in few reports no seed set has been observed for *S. alatum* during hybridization studies *S. radiatum* is placed in gene pool-3 due to lack of capsule formation , no seed set and use of embryo rescue methods (Dasharath et al. 2007). A recent phylogenetic reconstruction based on two chloroplast loci also supports this categorization as *S. indicum* and *S. indicum subsp. malabaricum* were seen to have a closer affinity. *S. prostratum* appeared to be a recent divergence in comparison to *S. alatum*(Figure 1). Interestingly, the wild species of sesame are known to exhibit tolerance and resistance to different pests and diseases and some abiotic stresses.

Wild Species as Resources for Stress Resistance:

The wild species of sesame are known to exhibit tolerance and resistance to different pests and diseases as they can grow under adverse conditions Several wild Sesamum species have proved resistant to biotic and abiotic stress. S. angustifolium is the most drought resistant species as it shows a high percentage of fruit set (89%) during the dry season. Some of the adaptive features, for example, in wild species are fleshy roots, small linear leaves, a large number of stomata located at the adaxial surface, hairiness, and increased fruit set in the dry season, when the cultivated sesame in the vicinity had dried out. Species *agustifolium* with gray seed is reported to be a drought resistant donor and species *S. radiatum*, a foliar disease resistant source to improve commercial sesame.

S. alatum immune to phyllody, and two other species – *S. laciniatum* and *S. radiatum* – were resistant to Antigastra catalaunalis (shoot webber). The species *S. malabaricum* has the unique character of withstanding heavy rainfall when compared with cultivated sesame. *S. prostratum* was also observed to be resistant to many pests and diseases. This species is drought resistant and suitable for sandy tracts. *S.laciniatum* resistant to drought and also to Antigastra. shoot webber resistance in *S. malabaricum*, *S. alatum*, *S. laciniatum*, and *S. radiatum*; powdery mildew resistance in *S. malabaicum, S. alatum* and *S. occidntale* and **S. radium** is resistant to phytopthtora blight, fusarium wilt laf blight, and seedling blight.

Sesamum species and their chromosome number.

2n=26	2n=32	2n=64
S. indicum L	*S. angolnse Welw*	S.radiatum schum and thonn.
S. alatum Thonn	*S. augustifolium Engl*	-
S capense Burm.f	*S. laciniatum Willd*	-
S.malabaricum Burm.	*S.latifolium Gillett*	-
-	*S. prostatum Retz*	-

Wild species and their descriptions.

species	Chromosome number	Morphological description	Desirable characters
S. indicum	26	Annual, erect, moderately branching, white flowers, anthers yellowish white, yellow glands present, medium long cylindrical capsules, smooth seeds with thin Testa	High quality oil and seed
S. alatum	26	Annual, erect, highly branching, linear, trim, penta-lobed entireleaves, dark purple flowers, anthers purple, purple glands present, deeply grooved cylindrical capsules, winged seeds with thick testa.	Resistant to phyllody and antigastra
S. malabaricum	26	Annual, erect, profusely branching, heteromorphic linear to three lobed entire leathery leaves, purple flower with dark purple lip, anthers yellowish white, prominent yellow glands, cylindrical capsules, rough seeds with thick testa.	Resistant to water logging, donor for cytoplasmic male sterility.
S. mulayunum	26	Annual, erect, profusely branching, purple flower with dark purple lip, anthers yellowish white, prominent yellow glands, long cylindrical capsules, rough seeds with thick testa.	Resistant to fusarium wilt and gall fly

S. prostratum	32	Perennial, prostrate, profusely branching, coarse leathery leaves with serrated margin, dark purple flowers with purple anthers, yellow glands absent, medium laterally compressed tough capsules seeds with thick testa	Resistant to antigastra and salinity and non shattering capsules.
S. laciniatum	32	Perennial, prostrate, profusely branching, deeply dissected coarse leaves, deep purple flowers with purple anthers, yellow glands absent, small laterally compressed tough capsules, deeply reticulate seeds with thick testa.	Resistant to antigastra and drought and non shattering capsules
S. occidentale	64	Annual, erect, profusely branching, coarse linear entire leaves, purple flowers with light purple anthers, yellow glands present, long cylindrical capsules, rough seeds with thick testa.	Resistant to drought
S. radiatum	64	Annual, erect, moderately branching, coarse broader leaves, purple flowers and anthers, yellow glands present, long laterally compressed capsules, rough seeds with thick testa.	Resistant to drought

Conclusion

The wild species of sesame are known to exhibit tolerance and resistance to different pests and diseases as they can grow under adverse conditions Several wild Sesamum species have proved resistant to biotic and abiotic stress so it can be used for crop improvement of cultivated sesame spcises and full fill our breeding objectives.

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UNMANNED AIR VEHICLE BASED PLATFORMS FOR HIGH THROUGHPUT FIELD PHENOTYPING IN MAIZE

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Introduction

Global warming a profound phenomenon of human activity has risen as a major threat to agriculture that feeds the growing human population. Climate change with rising temperatures and unpredictable weather patterns have made crops vulnerable to abiotic stresses such as drought and heat waves, as well as emergence of new pests and diseases. Yield losses due to biotic and abiotic stresses account for nearly 10% and 39% yield losses in Maize. (Gong et al., 2014; Daryanto et al., 2016).

It has been well established that the genetic improvement of maize for yield, tolerance to biotic and abiotic stress could result in genetic gains However, progress has been slow since these are complex quantitative traits controlled by multiple genes and signaling pathways, highly influenced by genotype × environment effects, and characterized by low yield heritability. Traditional screening techniques are deployed for identifying high yielding, stress tolerant cultivars under field or artificial conditions. For example, drought and heat tolerant genotypes are conventionally developed by screening the maize germplasm under induced drought stress with elevated temperatures to identify genotypes with superior performance. Traits such as canopy temperature, stomatal conductance, thylakoid membrane stability, stay green characteristic, waxy leaves, chlorophyll content, grain-filling duration, and grain yield. are measured to assess the physiological status of plants. Screening for pest and disease resistance involves plant infestation and observation of damage symptoms. However, the cost and time involved in precisely characterizing these agronomically important phenotypic traits on a large scale remains a bottleneck. With the advances in remote sensing techniques, it has now become a possible to conduct high throughput field based phenotyping for complex traits including drought and heat tolerance associated traits

Unmanned air vehicles for high throughput field based phenotyping

High throughput field based phenotyping is generally done using three different remote sensing approaches *viz.*, unmanned aerial vehicles (UAVs), proximal sensing and satellite based imagery. Among these, in recent years, unmanned aerial vehicles (UAVs) have become a popular field phenotyping platform in agricultural research experiments. UAV is a high resolution remote sensing tool that navigates at low altitude without a human pilot. The commonly used UAVs for high throughput field based phenotyping include helicopters, multi-rotors, fixed wing , flying wing and blimps. A typical UAV consists of an engine that is oil or electricity driven, an UAV body equipped with multiple sensors operated by remote control and a flight control system designed for the execution of entire flight operations and autonomous tasks. These carrier systems efficiently capture high resolution images both spatially and temporally (Yang et al., 2017).

Phenological metrics such as plant morphological traits, physiological status under abiotic stress, nutritional disorders and disease detection can be acquired based on spatially explicit UAV images acquired by the high resolution cameras that offer near-real-time spectral information, which is useful for detecting gradual changes in crop phenology. UAV images can be continuously acquired under user-defined ground sampling distances and temporal intervals, which limit atmospheric perturbations such as cloud cover.

Sensors deployed in UAVs for acquiring phenological traits

Various sensors are mounted in the UAV for acquiring the images of plant morphology. These include visible light sensors, multispectral sensors, hyper spectral sensors, infrared thermal imaging sensors, and light detection and ranging (LIDAR) sensors .

Visible light sensors

Visible light sensors include digtial cameras such as RGB cameras mounted in UAV are capable of acquiring both gray and colour images to study phenotypic traits. However, they are suitable for recording only clear visible symptoms. The acquired images are preprocessed to get a homogenous image quality. Using these digital images, a high quality orthoimage displaying the status of phenotypic features during the crop growth period can be acquired using splicing softwares such as photoscan. However, the images

Multispectral sensors

These imagers can record radiations from visible and inviisble part of the electromagnetic spectrum and are used for monitoring crop growth. They are fast and efficient in capturing the spectral features of crop and widely used for field based phenotyping. However, they display low spectral resolution with less number of bands. These sensors have been used for recording leaf chlorophyll content, leaf nitrogen content, leaf area index as well as for yield and biomass prediction

Hyperspectral sensors

These sensors overcome the limitations of the multispectral imagers as they are capable of capturing the spectral features of crop phenotype with high spectral resolution and more number of bands. They have been used for phenotyping physiological traits like leaf chlorophyll content, nitrogen content, net photosynthesis rate, leaf area index. They are also useful tools in disease detection and yield prediction.

Thermal sesnors

These sensors use infrared detectors to sense and acquire infrared radiation over different time points enabling a time series analysis. These sensors have been widely applied to characterize plant responses under drought and temperature stress. Parameters such as transpiration rate, stomatal conductance, leaf water potential, net photosynthesis, canopy temperature are acquired in a non destructive way using these sensors. However, specific algorithms are required for image processing and data extraction. Moreover, heeterogenous canopy and pixels obtained from soil and crop affect the data extraction process.

LIDAR

LIDAR (Light detection and ranging) is a remote sensing tool that emits a pulsed laser light towards a target object and measures the time taken for the reflected light to reach the receiver. They have mainly been used for terrestrial applications such as surveying area under forest cover, but find limited applicability in individual crop based phenotyping. UAVequipped with LIDAR has been used for measuring plant height in maize hybrids and inbred lines

Image processing

The images acquired from the various remote sensors exhibit geometric and radiation distortion, which needs to be corrected. Geometric correction is achieved either through positioning and orientation system (POS) or Global positioning system (GPS). Radiation and angular distortion seen in images acquired by hyperspectral and multispectral imaging sensors needs to be corrected for obtaining precise spectral characteristics. Radiation correction is obtained by spectral radiation calibration based on different kinds of regression and logarithmic models. Angular correction is achieved through radiative transfer models. Following these correction, the spectral features are extracted through dimensionality reduction and machine learning approaches and used for predicting and quantifying the phenotypes.

Applications of UAV for high throughput field phenotyping in Maize

UAV mounted sensors have been used for phenotyping several geometric traits in maize. UAV equipped with LIDAR has been used for measuring plant height in maize hybrids and inbred lines. Geometric traits such as plant height, leaf area index and lodging resistance were measured in two maize breeding trials using UAV mounted with digital cameras (Su et al., 2019). The leaf nitrogen content in 233 maize inbred lines was estimated based on canopy coverage and greenness rating of images acquired using UAV equipped with RGB sensor (Rodene et al., 2022). Shu et al. (2022) used UAV equipped with both digital and multispectral sensors to improve the estimation accuracy of phenotypic traits such as leaf area index, fresh weight and dry weight of maize.

To identify drought tolerant genotypes, UAV with RGB, optical and thermal imagery sensors have been used to measure foliar temperature, canopy temperature and stomatal conductance under water stress condition (Zhang et al., 2019a; Brewer et al., 2022). Zhang et al. (2019b) mapped the water stress status in maize based on nine vegetation indices derived from UAV multispectral images. UAV based multispectral and thermal information has been used to derive three drought indices that can precisely monitor crop water status (Cheng et al., 2023). Based on UAV thermal images acquired, Pradawet et al., 2023 showed that there was a strong correlation between crop water stress index and stomatal conductance and predicted yield under drought stress was done in maize. UAV based images have also been used to detect fall army worm symptoms and monitor leaf spot disease in maize (Ishengoma et al., 2022; Jia et al., 2023)

Challenges

UAV based platform is gaining momentum as a powerful tool in field based phenotyping due to its high resolution, low cost, and operational efficiency. However, image processing is a complex phenomenon that is highly demanding. Geometric and radiation correction requires internal calibration settings. Availability of image processing softwares, suitable algorithms and models to extract the spectral features and derive phenotypic indices is quite challenging and time consuming. Nevertheless, UAV based phenotyping is robust and paves the way for understanding crop dynamics and performing genome wide association analysis to dissect the genetic loci underlying complex traits.

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SONORAN MILLET (*PANICUM HIRTICAULE*) A RARE NUTRIA-MILLET

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Introduction

The genus *Panicum* is defined as having unawned spikelets with 2 florets, the first floret sterile or staminate, and the second floret bisexual with a rigid lemma that clasps the palea. *Panicum hirticaule* is an erect to decumbent annual and Summer ephemerals, highly variable in size, 20–60 cm tall (sometimes much taller elsewhere), often with a single main axis; roots often weakly developed. Plants usually with prominent, spreading, coarse and usually bulbous-based hairs, especially on stems, leaf sheaths, lower leaf-blade surfaces, or rarely glabrate or glabrous; flowering branches and spikelets glabrous. Panicles erect, the branches mostly straight, or drooping with weight of the grain on large, robust plants with especially large panicles.

Spikelets 2–4 mm long. Lower glumes 1.5–2 mm long, ½–¾ as long as the spikelets; glumes and lemmas with conspicuous longitudinal (parallel) green veins. Lower floret sterile. Fertile lemmas smooth and shiny, 1.6–2 × 0.7–1 mm, shiny cream-white, becoming dark brown with age. Often common along major drainage ways and also on rocky slopes, sandy plains, and many other habitats. Widespread and seasonally common nearly throughout Organ Pipe and at least the eastern part of Cabeza Prieta. Documented in the Ajo Mountains for 20,500 years, these fossils clearly are subsp. hirticaule. Widespread in the Sonoran Desert; southwestern USA to South America and the West Indies. Like many of the annual *Panicum spp*. in this species was once classified as a variety of *P. capillare* (Gould 1951). It is distinguished from *P. capillare* by its shorter pedicels < 8 mm long and its panicle branches that tend to be more stiff, straight, and ascending rather than gently curving and widely diverging as in *Panicum capillare*. FNA recognizes 3 varieties, all found in the Southwest. *P. hirticaule var . hirticaule* is most common, with blades rounded at the base; lower paleas less than 1/2 as long as the upper florets; and erect panicles. *P. hirticaule var. stramineum* has blades with a clasping base; panicles often nodding; herbage glabrous or sparsely pilose; culms < 70 cm tall; and spikelets 3.2-4. mm. *P. hiriticaule var. sonorum* has blades with a clasping base; panicles often nodding; hirsute herbage; culms > 70 cm tall; and spikelets 3-3.3 mm.

Distribution

In North America it is native to the South western United States and Mexico. Its distribution extends throughout central and South America. Its grows in many types of habitat, including distributed areas.

Introduced into: Washington

Native : Arizona, California, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Galápagos, Guatemala, Haiti, Honduras, Mexico Gulf, Mexico Northeast, Mexico Northwest, Mexico Southeast, Mexico Southwest, Netherlands Antilles, Nevada, New Mexico, Nicaragua, Oklahoma, Panamá, Peru, Texas, Venezuela. (**Figure 1)**

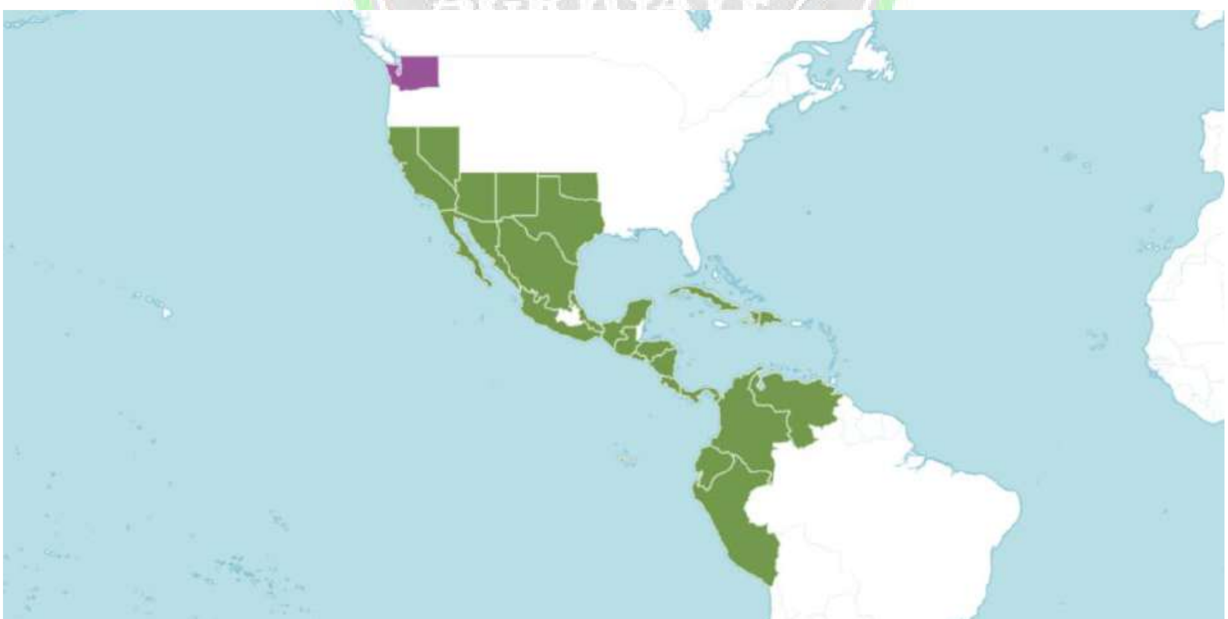

Figure 1. Geographical disturbition *Pancium hirticaule*

INTRODUCED

SCIENTIFIC CLASSIFICATION

Panicum hirticaule is known by the common names **Mexican panicgrass** and **roughstalked witchgrass**. (Figure 2)

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Monocots
Clade	Commelinids
Order	Poales
Family	Poaceae
Subfamily	Panicoideae
Genus	*Panicum*
Species	*hiriticaule*

Figure 2. *Pancium hirticaule*

BOTANICAL DESCRIPTION

Etymology: *Panicum* is a classical Latin name for millet, *hirticaule* means hairy-stemmed.

Ecology: Found on dry slopes and plains, sandy washes, and open woodlands below 7,000 ft(2134 m) and ponderosa pine forests.

Habit: annual

General: Annual grass, 20-110 cm tall; stems erect to decumbent, the nodes glabrous or shortly hirsute; herbage glabrous or hispid with papillose-based hairs.

Vegetative: Sheaths shorter than the internodes, greenish to purplish, glabrous or with papillose-based hairs, ciliate on one margin and glabrous on the other; collars hirsute; ligules of hairs, 1-3 mm; blades flat with clasping bases, 3-30 cm long, 3-30 mm wide,

Inflorescence: Panicles 9-30 cm long, 5-8 cm wide, erect or nodding, primary branches divergent, secondary branches and pedicels appressed, confined to the distal 2/3 of the primary branches; spikelets 2-4 mm long, ovoid, reddish-brown with prominent veins, 2-flowered, the first floret reduced to a sterile lemma and the second floret fertile. Lower glumes 3-5-veined; upper glumes 7-11-veined; lower lemmas similar to the upper glumes, 9-veined; upper lemma indurate, 2 mm long, ellipsoid, smooth or conspicuously papillate, shiny, stramineous.

Fruit: caryopsis, Caryopsis ellipsoid, longitudinally grooved, hilum long-linear.

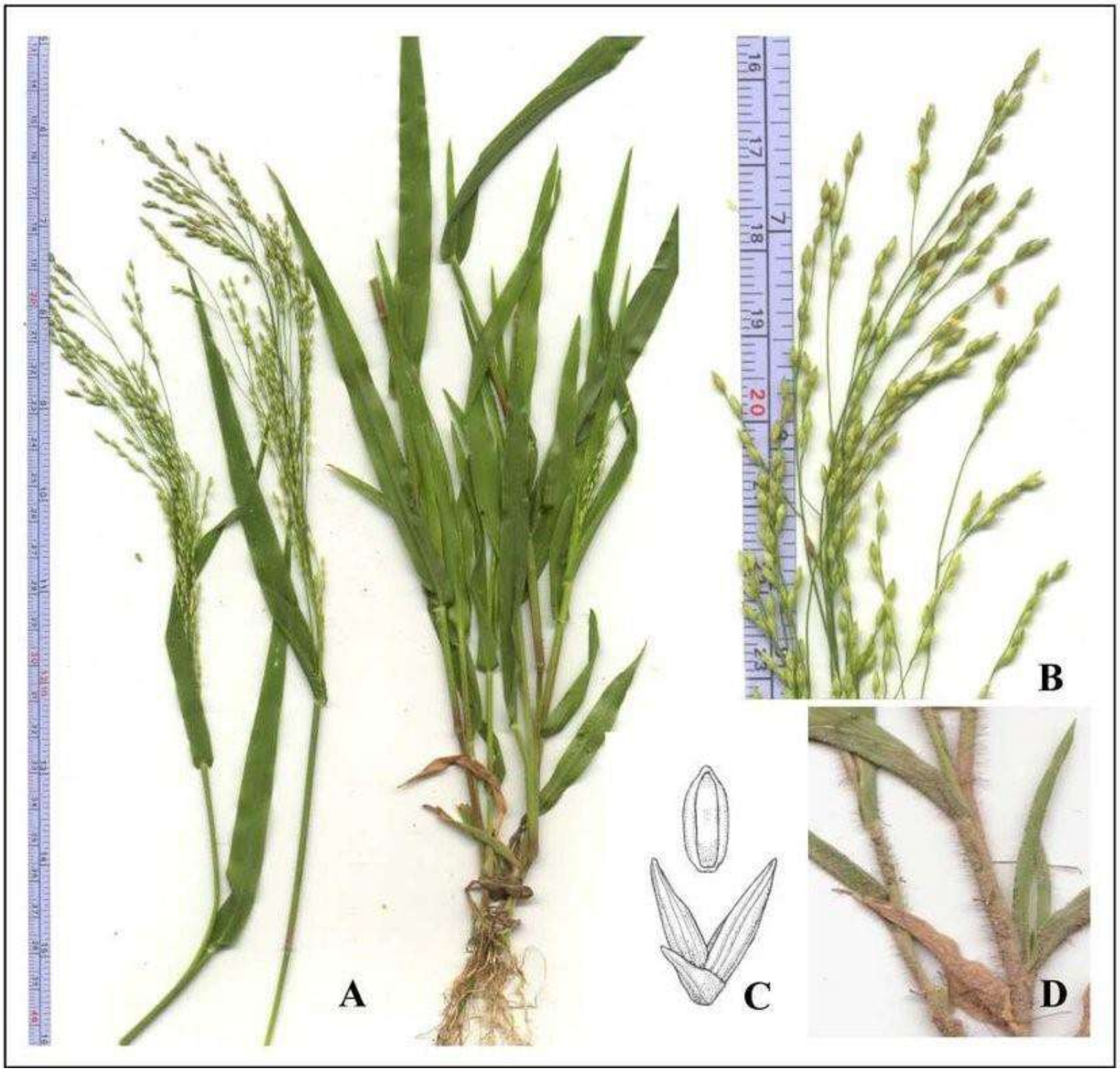

Fig. 3. ***Panicum hirticaule***. (A & B) Young flowering plants,; (C) spikelet spread apart showing glumes and sterile lemma (below) and fertile floret (above); (D) portion of plant showing pubescence

SUB-SPECIES BELONG TO *Panicum hirticaule*

(a) Panicum hirticaule subsp. Hirticaule

Culms 11-70 cm tall, usually simple; nodes usually hirsute. Sheaths hirsute, hairs papillose-based; Blades 3-16 mm wide, rounded basally. Panicles erect. Spikelets 1.9-3.3 mm. Lower paleas less than 1/2 as long as the upper florets. 2n = 18, 36

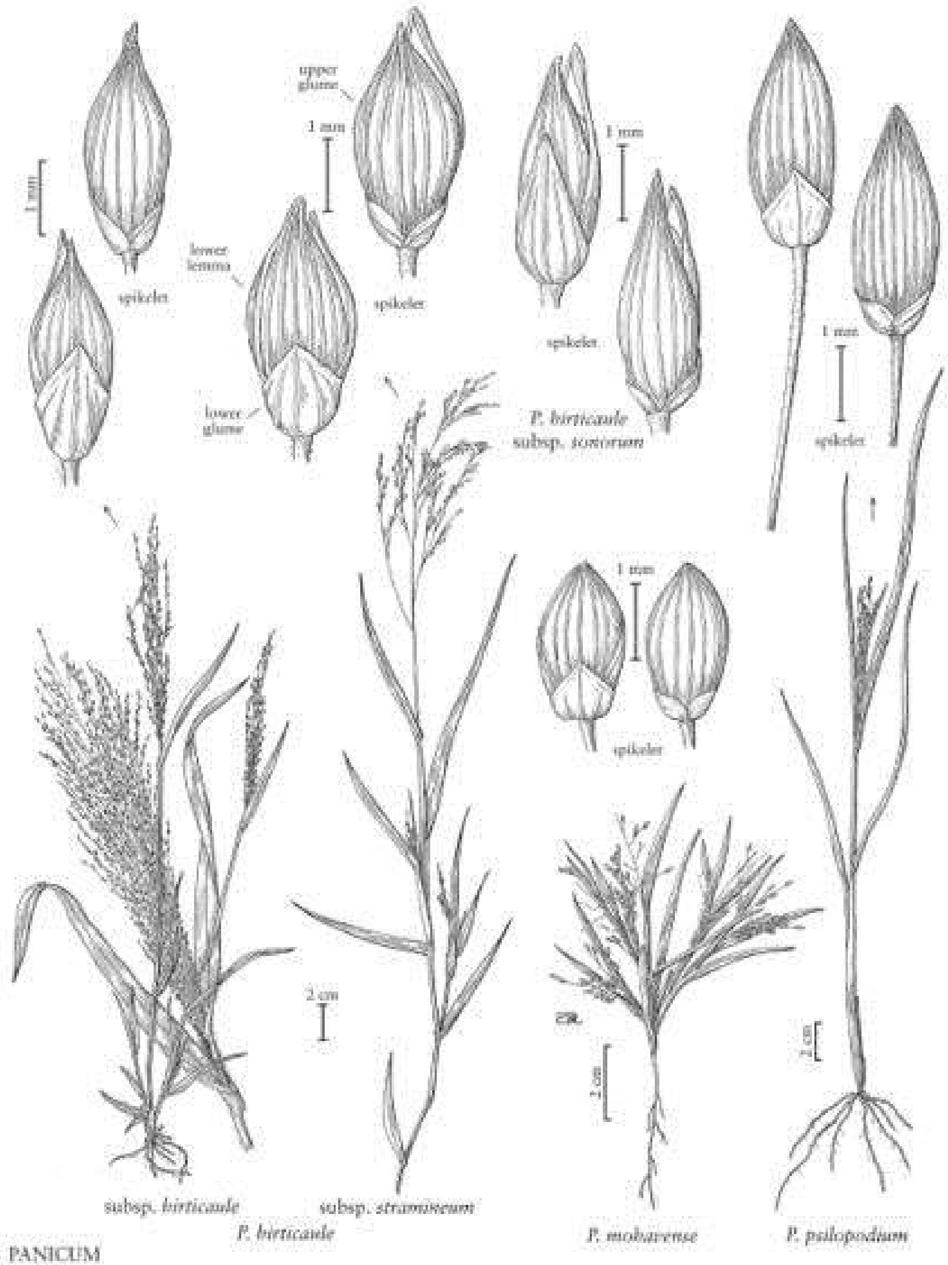

Fig. 4. Sub-species belong to *Panicum hirticaule*

***(b) Panicum hirticaule subsp. sonorum* (Beal) Freckmann & Lelong**

Hitchcock and Chase (1910: 65-68) suggested that P. sonorum was a cultivated form of P. hirticaule, being large in all its vegetative parts. Wild and weedy Panicum sonorum occurs naturally on floodplains in southern Arizona and along the western slopes of the Sierras into Honduras and E1 Salvador.

Plants of *P. sonorum* grow as tall as 1.5 m under cultivation and under ideal conditions in the wild. Characteristic are the 10-40 cm tong panicles, with densely-flowered and pendent branches. Spikelets are typically chocolate or cream colored. Slender wild plants tiller profusely, with each tiller producing a terminal panicle that yields up to 1,500 spikelets with 1.2-1.8 mm long mature grains. Robust plants (weeds and domesticates) also have tillers, but tillering is more synchronized with the result that most panicles on a plant mature simultaneously. Panicles of weeds and domesticates are generally larger than those of wild plants, with each panicle yielding up to 2,500 grains that are 1.8-3.0 mm long. Synchronized tillering and large fruits suggest that weedy plants originated as an escape from cultivation.

Table 1. Morphological studies of two distinct races of *P. sonorum*

TRAITS	**DOMESTICATED RACE**	**WILD RACE**
Grain size	Large (1.8-3.0 mm)	Small (1.2-1.8 mm)
Color	Pale cream or pale chocolate	Dark cream to dark chocolate
Germination	Lacks dormancy	Highly dormant
Dispersal	Spikelets usually disarticulate with fruils intact	Florets readily disarticulate
Fruitcase	Soft and sweet	Indurated and bitter
Panicle length	10-40 cm	15-35 cm
Position	Mostly extruded from leaf sheath	Partially enclosed by leaf sheath
Culm diameter	3.0-7.0 mm	3.0-4.0 mm
Height	Erect to slightly decumbent	Decumbent to almost prostrate
Tillering	Few, more or less synchronous	Numerous, not synchronous
Leaf blade	Essentially glabrous to sparsely hirsute, hairs short	Sparsely hirsute, hairs long
Width	12.0-32.0 mm	13-22 mm
Length	22-41 cm	13-32 cm
Habitat	Man-disturbed	Open-woodland

Morphological studies (Table 1) indicate 2 distinct races of *P. sonorum*, one wild and the other a domesticate with associated weeds. Domesticates differ from wild plants primarily in having larger, paler seeds; partial loss of natural seed dispersability; immediate germination of a high percentage of planted seeds; loss of bitterness in the fruits; robustness; and more synchronized tillering. Some plants of the domesticated race show tendencies toward being more erect with thicker culms, open panicles, and more globose fruit (Table 1). On the basis of these characteristics, the weed, *P. sonorum*, will be referred to as part of the domesticated race, and the slender plants as the wild race. The terms wild, weed and domesticate are used in the sense of Harlan and de Wet (1971) and de Wet and Harlan (1975).

(c) Panicum hirticaule subsp. stramineum **(Hitchc. & Chase) Freckmann & Lelong**

Culms 20-70 cm, robust, usually freely branching; nodes glabrous or sparsely hirsute, hairs papillose-based. Sheaths glabrous or sparsely hirsute, hairs papillose-based; blades 4-30 mm wide, glabrous or sparsely hirsute, hairs papillose-based, cordate, clasping basally. Panicles nodding. Spikelets 3.2-4 mm; lower paleas more than 1/2 as long as the upper florets.

CUTIVATION AND PROPAGATION

Panicum hirticaule is a warm-season grass that is suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in nutritionally poor soil and has suitable pH: mildly acid, neutral and basic (mildly alkaline) soils. It cannot grow in the shade. It prefers dry or moist soil. Propagation is by seed or division of clumps.

BENEFITS

a) *Panicum hirticaule* is used as an ornamental grass in landscaping and as a cover crop. It is also used as a forage crop for livestock and wildlife, and as a soil stabilizer.
b) Seeds were ground into a meal and used for making flour and bread by the Cocopa.
c) It is relished by grazing animals and harvested as a wild hay around Alamos in southwestern Sonora, where ranchers welcome its forage value.

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VIRUS INDEXING USING PCR IN TISSUE CULTURED PLANTS

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Introduction

Indexing is a procedure to determine the presence or absence of viruses not readily transmitted mechanically. A virus-indexed variety is one that has been tested and deemed free of the viruses it was tested for up to the point of testing. The vegetatively propagated plants suffer from multiple virus or virus-like diseases that deteriorate the health status of the plant. This problem is extensively observed in perennial woody plants. However, growing healthy plants is only possible by the identification, development, and propagation of virus-free clones. Tissue culture, the method of growing isolated tissues and organs, enables the elimination of plant viruses and the propagation of virus free materials. Meristem culture is a widely used method for virus eradication from horticultural plants. Mostly the apical meristems are often virus free. Tissue culture is the *in vitro* aseptic culture of cells, tissues, organs or whole plant under controlled nutritional and environmental conditions often to produce the clones of plants.

The resultant clones are true-to type of the selected genotype. Apart from their use as a tool of research, plant tissue culture techniques have in recent years, become of major industrial importance in the area of plant propagation, disease elimination, plant improvement and production of secondary metabolites. A single explant can be multiplied into several thousand plants in relatively short time period and space under controlled conditions, irrespective of the season and weather on a year round basis. Endangered, threatened and rare species have successfully been grown and conserved by micropropagation because of high coefficient of multiplication and small demands on number of initial plants and space. The appearance of genetically modified organisms on the food market a few years ago, and the demand for more precise and reliable techniques to detect foreign (transgenic or pathogenic) DNA in edible plants, have been the driving force for the introduction of real-time PCR techniques in plant research. This was followed by numerous fundamental research applications aiming to study the expression profiles of endogenous genes and multigene families.

Since then, the interest in this technique in the plant scientist community has increased exponentially. This review describes the technical features of quantitative real-time PCR that are especially relevant to plant research, and summarizes its present and future applications. Polymerase chain reaction (abbreviated PCR) is a laboratory technique for rapidly producing (amplifying) millions to billions of copies of a specific segment of DNA, which can then be studied in greater detail. PCR is commonly used in plant genetics and molecular breeding to copy a specific DNA fragment from the genome of an individual as a step in the process of molecular marker assisted selection. The use of PCR to copy a specific portion of a genome is analogous to photocopying a specific page of a book.

"I may not be the natural one, but I try the best for you…"

-in vitro culture

PREPARATION OF THE SAMPLES

The tests should preferably be performed on fresh plant extracts or by direct tissue-print or squash of fresh sections of plant material immobilized on membranes. Depending on the type of virus (e.g. particle stability), it may be possible to use freeze-dried or frozen plant material or extracts. Information regarding the possibility of bulking depends on several factors including the virus concerned, the type of material to be tested, and the antiserum and needs to be validated. This information is provided when available in pest-specific Diagnostic Protocols. The tissue/buffer ratio for the preparation of the extract is determined depending on the type of tissue and is about 1/10 w/v (usually 0.2 g of fresh plant material in 2 mL).

SAMPLE PREPARATION FOR TISSUE-PRINT (WITHOUT PLANT EXTRACT PREPARATION)

For immobilization of samples for tissue print on commercial nitrocellulose membranes clean cuts on tender shoots, leaf petioles, fruit peduncles or flowers should be made. The freshly made sections should be pressed carefully against the membrane. The trace (print) is left to dry for a few minutes. For routine testing at least two prints from different sections per selected shoot or peduncle should be performed and one per leaf petiole or flower. Another option for viruses not restricted to the vascular area is to squash the material on the membrane. For immobilization for squashes the plant material is gently pressed on the membrane and the trace is left to dry as above.

MOLECULAR METHODS TO DETECT THE VIRUS PRESENCE

This technique detects the presence of viral nucleic acid in the plant materials to be inoculated. Among several molecular techniques used for the detection of the virus, the most popular one is polymerase chain reaction (PCR). Before initiating PCR, a reverse transcription step is performed, as most of the viruses have RNA as the genome. PCR is an effective and sensitive tool that is used to detect viruses in woody plants, where the genetic diversity of the viruses infecting the plants is very high. The points that should be kept in mind while performing PCR is the designing of primers and templates to be used for the identification purpose. The other modern techniques used over PCR include real-time quantitative PCR (qPCR), multiplex qPCR, and next-generation sequencing (NGS) technologies. The only limitation of the molecular methods is the high cost of the techniques. However, for broad screening of viruses, in the vegetatively propagated plant materials, these are best to use in combination with other techniques.

PRINCIPLE

PCR is based on using the ability of DNA polymerase to synthesize new strand of DNA complementary to the offered template strand. Because DNA polymerase can add a nucleotide only onto a preexisting 3'-OH group, it needs a primer to which it can add the first nucleotide.

COMPONENTS

The key ingredients of a PCR reaction are **Taq polymerase, primers, template DNA, and nucleotides** (DNA building blocks). The ingredients are assembled in a tube, along with cofactors needed by the enzyme, and are put through repeated cycles of heating and cooling that allow DNA to be synthesized.

USE

- PCR (polymerase chain reaction) tests are a fast, highly accurate way **to diagnose certain infectious diseases and genetic changes**. The tests work by finding the DNA or RNA of a pathogen (disease-causing organism) or abnormal cells in a sample.

- The polymerase chain reaction has been elaborated in many ways since its introduction and is now commonly used for a wide variety of applications including **genotyping, cloning, mutation detection, sequencing, microarrays, forensics, and paternity testing**. Typically, a PCR is a three-step reaction.

STEPS

- **Step 1 - Denaturation. The solution contained in the tube is heated to at least 94°C (201.2°F) using a thermal cycler. ...**
- **Step 2 - Annealing. ...**
- **Step 3 - Extension. ...**
- **Step 4 - Analysis with Electrophoresis.**

Typically, PCR consists of a series of 20–40 repeated temperature changes, called thermal cycles, with each cycle commonly consisting of two or three discrete temperature steps (see figure below). The cycling is often preceded by a single temperature step at a very high temperature (>90 °C (194 °F)), and followed by one hold at the end for final product extension or brief storage. The temperatures used and the length of time they are applied in each cycle depend on a variety of parameters, including the enzyme used for DNA synthesis, the concentration of bivalent ions and dNTPs in the reaction, and the **melting temperature** (T_m) of the primers. The individual steps common to most PCR methods are as follows:

• ***Initialization***:

This step is only required for DNA polymerases that require heat activation by **hot-start PCR.** It consists of heating the reaction chamber to a temperature of 94–96 °C (201–205 °F), or 98 °C (208 °F) if extremely thermostable polymerases are used, which is then held for 1–10 minutes.

• ***Denaturation***:

This step is the first regular cycling event and consists of heating the reaction chamber to 94–98 °C (201–208 °F) for 20–30 seconds. This causes **DNA melting,** or denaturation, of the double-stranded DNA template by breaking the **hydrogen bonds** between complementary bases, yielding two single-stranded DNA molecules.

• ***Annealing***:

In the next step, the reaction temperature is lowered to 50–65 °C (122–149 °F) for 20–40 seconds, allowing annealing of the primers to each of the single-stranded DNA templates. Two different primers are typically included in the reaction mixture: one for each of the two single-stranded complements containing the target region. The primers are single-stranded sequences themselves, but are much shorter than the length of the target region, complementing only very short sequences at the 3' end of each strand.

It is critical to determine a proper temperature for the annealing step because efficiency and specificity are strongly affected by the annealing temperature. This temperature must be low enough to allow for hybridization of the primer to the strand, but high enough for the hybridization to be specific, i.e., the primer should bind *only* to a perfectly complementary part of the strand, and nowhere else. If the temperature is too low, the primer may bind imperfectly. If it is too high, the primer may not bind at all. A typical annealing temperature is about 3–5 °C below the T_m of the primers used. Stable hydrogen bonds between complementary bases are formed only when the primer sequence very closely matches the template sequence. During this step, the polymerase binds to the primer-template hybrid and begins DNA formation.

- ***Extension/elongation*:**

The temperature at this step depends on the DNA polymerase used; the optimum activity temperature for the thermostable DNA polymerase of *Taq* polymerase is approximately 75–80 °C (167–176 °F), though a temperature of 72 °C (162 °F) is commonly used with this enzyme. In this step, the DNA polymerase synthesizes a new DNA strand complementary to the DNA template strand by adding free dNTPs from the reaction mixture that is complementary to the template in the 5'-to-3' direction, condensing the 5'-phosphate group of the dNTPs with the 3'-hydroxy group at the end of the nascent (elongating) DNA strand. The precise time required for elongation depends both on the DNA polymerase used and on the length of the DNA target region to amplify. As a rule of thumb, at their optimal temperature, most DNA polymerases polymerize a thousand bases per minute. Under optimal conditions (i.e., if there are no limitations due to limiting substrates or reagents), at each extension/elongation step, the number of DNA target sequences is doubled. With each successive cycle, the original template strands plus all newly generated strands become template strands for the next round of elongation, leading to exponential (geometric) amplification of the specific DNA target region.The processes of denaturation, annealing and elongation constitute a single cycle. Multiple cycles are required to amplify the DNA target to millions of copies. The formula used to calculate the number of DNA copies formed after a given number of cycles is 2^n, where n is the number of cycles. Thus, a reaction set for 30 cycles results in 2^{30}, or 1,073,741,824, copies of the original double-stranded DNA target region.

- ***Final elongation*:**

This single step is optional, but is performed at a temperature of 70–74 °C (158–165 °F) (the temperature range required for optimal activity of most polymerases used in PCR) for 5–15 minutes after the last PCR cycle to ensure that any remaining single-stranded DNA is fully elongated.

- ***Final hold*:**

The final step cools the reaction chamber to 4–15 °C (39–59 °F) for an indefinite time, and may be employed for short-term storage of the PCR products.

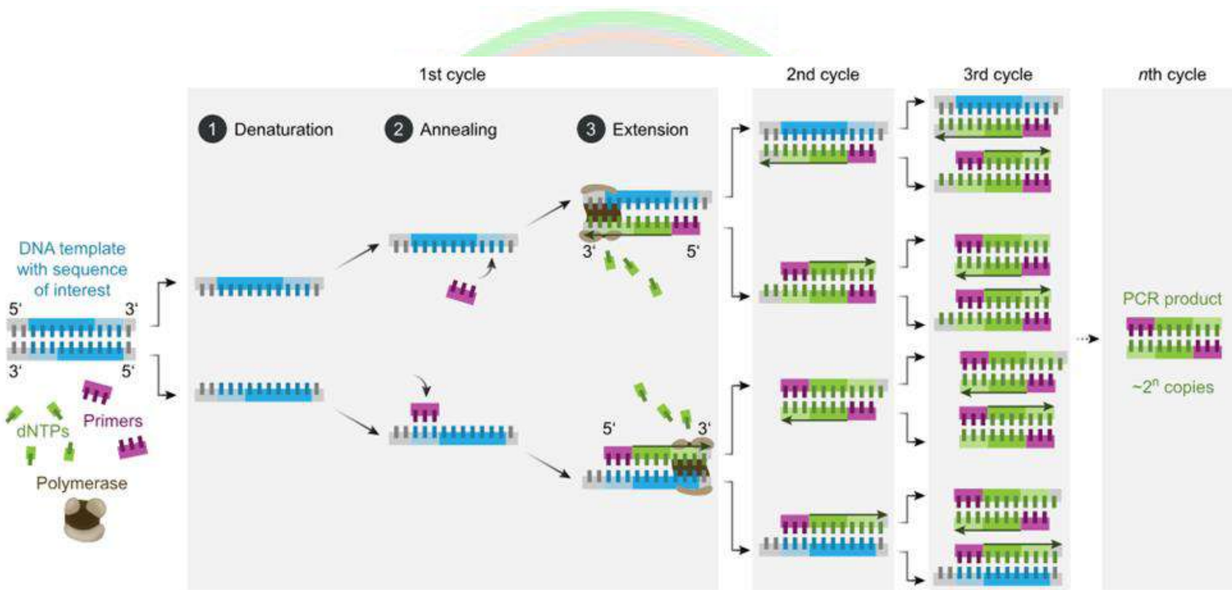

Fig.,1 Steps in PCR

Conclusion

The future of PCR appears promising. New versions of the classic PCR have drastically shortened the time required to reach a diagnosis while also reducing the number of false positives. Even in its present state, PCR has shown to match and even exceed the gold standard (culture and staining) in certain performance measures. PCR is a highly accurate and rapid method for duplicating genetic material. The discovery of thermostable polymerase enzymes has permitted the automation of PCR, thus reducing the manpower required to conduct these experiments. With the advent of qPCR, amplified products may also be quantified accurately. PCR has numerous important and diverse applications spanning research, medicine, law, ecology, and archaeology. There are some limitations to the technique including unwanted amplification of contaminated material, but on the whole PCR has become indispensible to the researcher and has been truly revolutionary to the life sciences. Many variants of PCR are continually being developed, including digital PCR, which permits faster and more precise results. The appliances currently required to undertake PCR are bulky and expensive, but newer more miniature devices are being developed to allow the benefits of PCR to be taken out of the laboratory.

"Ultimately what is not needed now is recriminations"

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WILD RICE GENETIC RESOURCES

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Introduction

Rice is a food crop of global importance, cultivated in diverse agro-climatic zones of the world. Worldwide, more than 3.5 billion people depend on rice for more than 20% of their daily calories. According to a report by the Food and Agriculture Organization (FAO), the global rice utilization in 2023-2024 is expected to be 522.0 million tons. World rice production has more than doubled from 257 million tons in 1966 to 680 million tons in 2010. This was mainly achieved through the application of principles of classical Mendelian genetics and conventional plant breeding. Further, rice productivity is continually threatened by several diseases (bacterial blight, blast, tungro virus, rice yellow mottle virus, sheath blight, etc.) and insects (plant hoppers, stemborer, and gall midge) including many abiotic stresses (drought, salinity, submergence, cold, heat, soil toxicities, etc.). To overcome these constraints particularly in the context of global climatic changes, there is urgent need to broaden the gene pool of rice; one of the options is to exploit the wild species of *Oryza* which are reservoirs of useful genes for rice improvement.

Species in the genus Oryza

Rice belongs to genus Oryza of family Gramineae made up of ~ 27 species that have been classified into 11 genome groups out of which are six diploid and five tetraploid. The two cultivated (diploid) species are

I. *Oryza sativa* - Asian rice

II. *Oryza glaberrima* - African rice

The three races in cultivated Asian rice are

i. Indica

ii. Japonica – Sticky rice

iii. Javanica

According to a 2005 study, rice germplasm can be divided into five major groups:

i) Aus ii) Indica iii) Aromatic iv) Temperate japonica v) Tropical japonica

The remaining ~ 25 species occur in wild populations and have become specialized to occupy a diverse set of environments around the world which includes both diploid and tetraploid forms. To date, the species and cultivars that make up the AA genome clade out of 11 groups have provided most of the genetic variation and resources that have led to the success of domesticated rice, while other genome clades have contributed relatively little to domestication. Therefore, wild species of rice occupy a number of genomic clades that are not yet represented by an assembly and undoubtedly include traits that would be desirable in domestic cultivars. The wild species therefore represent vast reservoirs of untapped genetic variation that could be harnessed for domestic rice improvement.

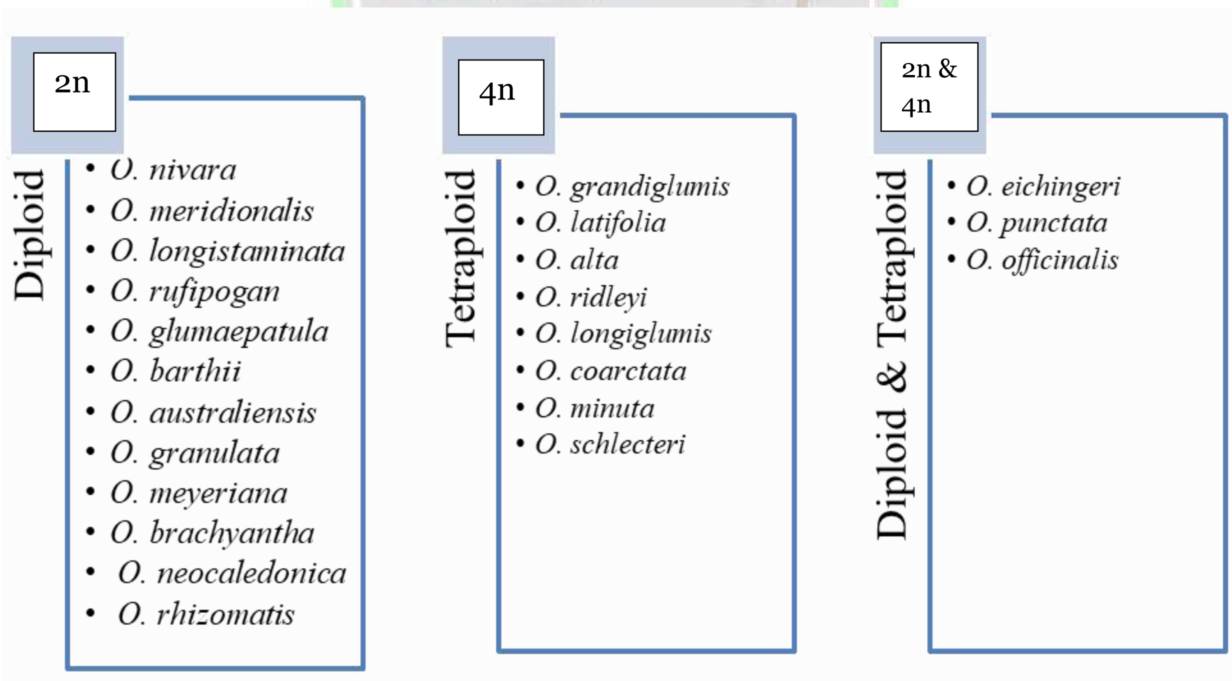

Fig.1 Wild species of genus *Oryza*

Diploid sp

1. AA genome (*O. sativa* complex)
   a. *O. barthi*
      - Resistant to BLB (Bacterial Leaf Blight) and stem borer.
      - Tolerant to heat and drought.
   b. *O. glumaepatula*
      - Resistance to root knot nematode, leaf and neck blast.
      - Drought tolerant.
   c. *O. longistaminata*
      - Resistant to BLB and lodging.
      - Tolerant to heat, drought and salinity.
   d. *O. meridionalis*
      - Tolerant to heat and Fe stress.
   e. *O. nivara*
      - Resistant to Grassy stunt virus, sheath blight, and GLH (Green Leaf Hopper).
   f. *O. rufipogan*
      - Resistant to Tungro disease, BLB (Bacterial Leaf Blight) and BPH (Brown Plant Hopper).
      - Tolerant to freezing, aluminium and soil acidity.
      - CMS (Cytoplasmic Male Sterile) source.
2. CC genome (*O. officinalis* complex)
   a. *O. officinalis*
      - Resistant to blast, BLB, BPH and WBPH (White Backed Plant Hopper).
   b. *O. rhizomatis*
      - Resistant to rice blast.
      - Flood tolerant.
3. EE genome (*O. officinalis* complex)
   a. *O. australiensis*
      - Resistant to BLB, BPH and WBPH.
      - Drought tolerant

4. FF genome
   a. *O. brachyantha*
      - Resistant to BLB, YSB (Yellow Stem Borer), leaf folder and whorl maggot.
5. GG genome (*O. meyeriana* complex)
   a. *O. granulata*
      - Resistant to BPH.
      - Shade and drought tolerant.
   b. *O. meyeriana*
      - Resistant to BLB, stripe bight and borer.
      - Tolerant to shade, drought and salt.
   c. *O. neocaledonica*
      - Drought tolerant.

Tetraploid sp

1. BBCC genome (*O. officinalis* complex)
   a. *O. minuta*
      - Resistant to blast, BLB and GLH.
2. CCDD genome (*O. officinalis* complex)
   a. *O. alta*
      - Moderate resistant to blast.
   b. *O. grandiglumis*
      - Moderate tolerance to blast and shows hyper-resistance response to pathogen infection.
      - Tolerant to submergence.
   c. *O. latifolia*
      - Resistant to BLB, BPH and WBPH.
3. HHJJ genome (*O. ridleyi* complex)
   a. *O. longiglumis*
      - Resistance to blast, BB.
   b. *O. ridleyi*
      - Resistance to blast, BB, tungro virus, stem borer, whorl maggot.
      - Tolerance to flooding.

4. HHKK genome (*O. ridleyi* complex)
   a. *O. schlechteri*

Diploid and tetraploid sp

1. BB, BBCC genome
   a. *O. punctata* (*O. officinalis* complex)
      - Resistant to rice yellow mottle virus, blast, BLB, BPH and GLH
2. CC genome
   a. *O. eichingeri* (*O. officinalis* complex)
      - Resistant to BPH, WBPH and GLH

   b. *O. officinalis* (*O. officinalis* complex)
      - Resistant to BLB, stem rot, thrips, BPH and WBPH
      - Heat tolerant.

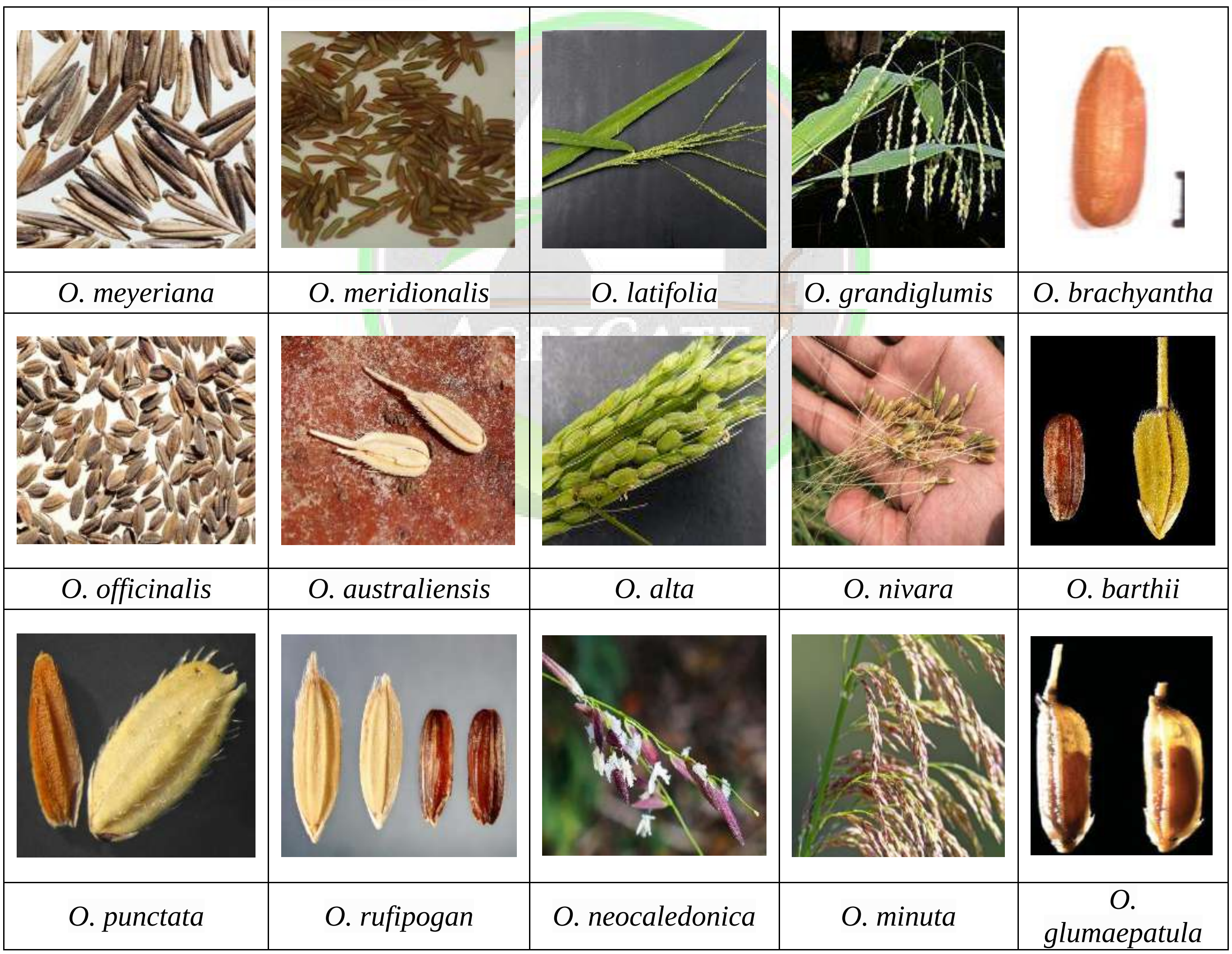

Fig 2. Few wild species of genus *Oryza*

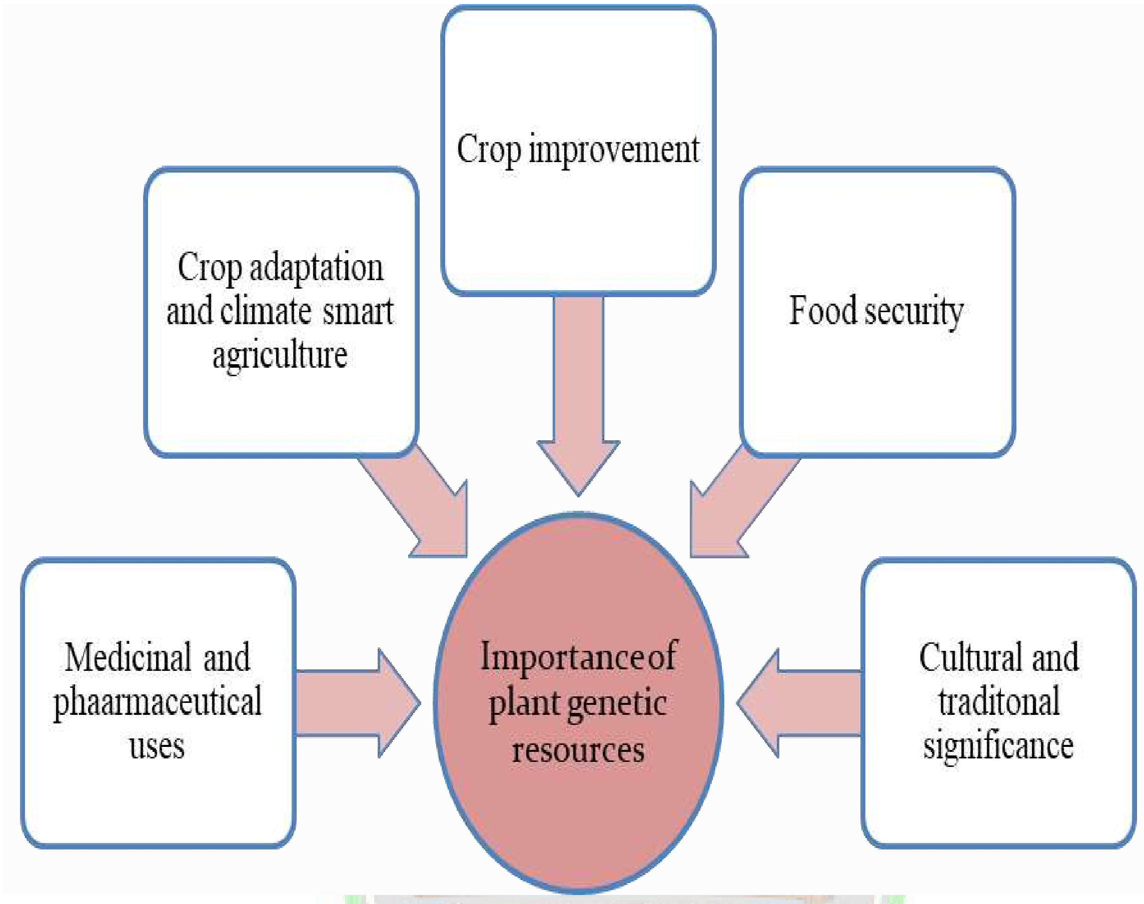

Fig 3. Importance of plant genetic resources

Conclusion

The wild species of rice are expected to harbor novel beneficial alleles which have been lost from cultivated rice during the process of domestication. This unchecked loss of alleles has made cultivated rice varieties more susceptible to the changing climatic conditions. Therefore, to develop climate-resilient rice crops, it is desirable to transfer the beneficial alleles from the wild rice species to the cultivated ones. In this direction, efforts are underway to completely unlock the genetic blueprint of the wild relatives of rice, which should facilitate the identification of novel alleles and their subsequent use in various rice-breeding programs.

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ANTHRACNOSE: A POSTHARVEST THREAT TO EXPORTING INDUSTRIES

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Introduction

Vegetables and fruits are essential components of a diet that is balanced for humans. The benefits of eating more fresh fruits and vegetables are widely supported by nutritionists and other medical professionals since these foods include complex chemical components called vitamins that are essential for good health and cannot be produced by the body. Tropical fruits are nutritional and having medicinal qualities which led to an increased awareness of their significance on a global scale.

Colletotrichum gloeosporioides causes anthracnose disease in a variety of crops worldwide affecting foliage, stems and fruits of crops such as mango, papaya, guava, custard apple, pomegranate and other subtropical fruits. The disease thrives in wet, humid and warm conditions. It is spread through various means including infected seeds, rain splash and moist winds. Anthracnose leads to pre-harvest and post-harvest losses causing fruit drop and rot. The fungi responsible for anthracnose produce conidia within black fungal fruiting bodies called acervuli. Lesions initially appear as small, dark spots on fruits, leaves, stolons and petioles, gradually enlarging with age. Conidial masses cover the lesion centre forming brownish areas often in a concentric ring pattern. Besides *C.gloeosporioides*, other species like *C.lindimuthianum, C. acutatum, C. abscissum*, *C. carthami, C. graminicola, C. fruticola* contribute to anthracnose disease. Anthracnose is a widespread and destructive disease that affecting variety of crops, particularly in warm and humid conditions leading to significant losses in both pre-harvest and post-harvest stages. Recently, Colletotrichum was recognized as the eighth most important group of phytopathogenic fungi globally, based on scientific and economic significance.*C. gloeosporioides*, particularly associated with anthracnose disease, poses a growing threat to global agriculture. More than 50 per cent of losses in fresh fruits and vegetables are attributed to Colletotrichum species. Delayed onset of disease symptoms in crops is devastating and leading to significant postharvest losses.

C. gloeosporioides causes severe losses in important tropical fruit crops such as papaya, mango, avocado and dragon fruit.The perishable nature of these fruits underscores the urgent need for technologies to reduce deterioration and extend shelf life, adding value for buyers and consumers.

1. Colletotrichum: A Versatile Fungi with Diverse Host Range

The primary causative agent of the fungal disease anthracnose, which kills fruits and causes enormous financial losses globally, is *Colletotrichum* spp. *Colletotrichum* is the tenth most destructive plant pathogenic fungus in the world, according to (Dean *et al.*, 2012). Numerous species in the genus *Colletotrichum* cause plant diseases to a broad spectrum of plants including both herbaceous and woody plants (Cannon., 2012). Although recent research has shown some well-known *Colletotrichum* species surviving in temperate regions and thus affecting temperate crops. The occurrence and effects of anthracnose disease caused by these species are most common in tropical and subtropical areas where the climatic conditions are warm and humid.

Colletotrichum is a large genus comprising several significant species that are major fungal pathogens causing diseases in tropical and subtropical fruits and vegetables. Virtually every crop worldwide is susceptible to one or more *Colletotrichum* species. The genus is linked to economically important diseases in cereals, grasses, legumes, vegetables, and fruits. Variations in the physiological maturity and adaptability of the host, the environment and the pathogen's associated virulence genes all influence how plant pathogenic fungi interact with their host plants throughout their life cycle (Newton *et al.*, 2010). Many plant diseases that cause significant output losses in numerous plant species in worldwide are found in the genus *Colletotrichum*. They are mainly known as post-harvest pathogens of fruits and vegetables, although there have also been reports of them causing infections of the leaves, stems, tubers, and seedlings in the field. *Colletotrichum* species show different lifestyles that vary between groups of species, with most species being able to sequentially switch between lifestyles (O'connell *et al.*, 2012). Fungi *Colletotrichum* exhibit different lifestyles as necrotrophic, hemibiotrophic, latent or quiescent and endophytic. Hemibiotrophic lifestyle ismost exhibited by the Colletotrichum (Munch *et al.*, 2008).

Colletotrichum species	Host plant	Reference
C. acutatum	Capsicum	Kim *et al.*,2004
C. acutatum	Strawberry	Curry *et al.*,2002
C. acutatum	Citrus leaves	Zulfiqar *et al.*,1996
C. gleosporioides	Chilli fruits	O'connel*et al.*,2004
C. destructivum	Tobacco	Shen *et al.*,2001
C. graminicola	Cereals and grass species	Crouch and Beirn 2009
C. coccodes	Potato	Chang *et al.*,2014
C. gleosporioides	Mango	Ismail *et al.*,2015
C. gleosporioides	Guava	Pandey *et al.*,1997
C. gleosporioides & *C. capsici*	Papaya	Torres-Calzada *et al.*,2013
C. boninense	Avacado	Silva-Rojas & Ávila-Quezada., 2011
C. truncatum	Dragonfruit	Vijaya *et al.*,2015

Colletotrichum species have the potential to cross infect a wide range of host and make difficult for their management because of the different kinds of life cycle they have (De Silva *et al.*, 2016).Specific gene families and biochemical interactions produced by certain enzymes and secondary metabolites generated at the host-pathogen interface significantly control the life cycles of Colletotrichum species.

2. *Colletotrichum* infection mechanism and pathogenicity

The majority of *Colletotrichum* species are soil- and seed-borne. While their conidia are transported by water splash, particularly during the rainy seasons and the ascospores are dispersed by air. Although the pathogen *Colletotrichum* is primarily associated with anthracnose disease, it also plays a role in other plant diseases as banana and straw berry crown rot, red rot in coffee berries and sugar cane and blotch in cowpea. Its economic repercussions are amplified by the capacity to cause this complex of disorders (Lenne, 2002). *Colletotrichum* is the source of anthracnose disease, which manifests as sunken necrotic lesions on leaves, fruits, stems, and even roots. Crown and stem rots, as well as seed blight are other symptoms (Lenne, 2002). With the help of aspersorium, a germinating spore, *Colletotrichum* attaches itself to the surface of the plant and grows into a hypha that penetrates the plant cuticle to enter the epidermal cells (Liao.,2012). While inside the host, the fungus develops and multiplies producing host-induced virulence effectors that support their survival. The pathogen enters successive stages of the infection process called the biotrophic phaseduring which the inside cells and tissues become infected but do not exhibit symptoms. The infection subsequently progresses to the necrotic phases during which the pathogen colonizes the tissues and cells causing the plant cells to die and leaving behind visible necrotic lesions (Liao., 2012).

According to O'Connell *et al*. (2012) the pathogen uses a multistage bitrophic infection strategy that involves the growth of appressoria that help with attachment, chemical and enzyme release for cuticle destruction and penetration and eventually necrotrophy.Additionally, it has been discovered that the generation of phytotoxic compounds by Colletotrichum facilitates successful infection and the potential to cause anthracnose disease. Certain phytotoxic metabolites have been studied in relation to different Colletotrichum species and their host plants. For example, it has been reported that *Colletotrichum capsici* produces the toxic metabolites colletotrichin, colletodiol, colletoketol, colletol and colleallol. These metabolites not only increase the ability of the plant to become infected but also decrease the germination of seeds, root and shoot growth, and even cause mortality in seedlings of *Capsicum annuum* chillies.

It has been found that *Colletotrichum gloeosporioides* releases ergosterol in the stems of *Artemisia annua* and colletotric acid in the stems of *Artemisia mongolica*. While *Colletotrichum truncatum* generates meso- and D (−)-butane}2, 3-diol, 2 hydroxymethylhexa-2, 4-dienol and colletruncoic acid methyl ester in soybean G. max, *Colletotrichum nicotianae* releases colletotrichin in tobacco *Nicotianatabacum*.The fungal pathogens also exudate macerating enzymes that enable them to successfully infect host plants (O'Connell *et al.*, 2012). Colletotrichum species produce the enzyme cellulase that catalyses the degradation of host cell walls (Anand *et al.*, 2008; Peeran *et al.*, 2014). Other enzymes produced by *Colletotrichum* species include pectinolytic enzyme, endo-polygalacturonases, protein kinases, glucanase and chitinase(Anand *et al.*, 2008; Peeran *et al.*, 2014). *Colletotrichum graminicola* and *C. higgisianum* produce candidate secreted effectors (CSEPs) which are actually effector proteins, according to a study by O'Connell *et al.*, 2012. Most plant pathogens, including *Colletotrichum* species, have been found to secrete protein effectors that reprogram host cell immunity thereby facilitating infection.

3. Various factors influence the transmission mechanism of infection

The disease development depends on the presence of the pathogen and environmental factors such as temperature, rainfall and humidity. Typically, the pathogen prefers high temperatures (ideally between 25 and 30 degrees Celsius) and high humidity. It is known that for *C. gloeosporioides* spores to germinate and form appressorium, they need free water or a relative humidity (RH) of greater than 95 per cent. Acervuli only release spores when there is an abundance of moisture present. The impact of environmental conditions on the formation and development of *C. gloeosporioides* infection structures, both on plant surfaces and *in vitro*. It was shown that the temperature range of 20 to 25°C was the most stimulating for the development of appressoria.The frequency of formation of penetration pegs was highest at 25°C. Spores germinated at RH as low as 95 per cent, but the percentage of spores germinating and forming appressoria increased as the RH approached 100 per cent. Studies also showed that approximately 18 per cent of the spores of *C. gloeosporioides* when incubated in lower RH (62 and 86%) for 4 weeks retained viability and were also capable of forming appressoria when RH increased to 100 per cent.

Isolates of *C. gloeosporioides* from different locations require considerable variation in the optimal temperature for germination and appressorium formation. Severity of disease depends on the weather, and the fungus is relatively inactive in dry weather. Sunlight, low humidity and temperature extremes (below 18°C or greater than 25°C) rapidly inactivate spores.The physical environment during storage had a significant role since the percentage of anthracnose severity was increased with an increase in relative humidity. Several reports indicated that fruits which are high in water content are susceptible to postharvest shriveling which will negatively impact the appearance and market potential of the fruit.

5.Control Mechanisms

Colletotrichum species have established defense mechanisms against plant immune factors, controlling them has been difficult. Over time, chemicals have been employed to stop the fungifrom spreading, but complete control has been difficult because the disease has developed resistance. Several widelyused fungicidessuch as propiconazole, bitertanole, hexaconazole, imazalii, carbendazim and thiabendazole have been employed to manage Colletotrichum species.

Pre-harvest Management

- Sprays applied during the flower emergence and fruit setting and monthly during the fruit maturation helps to maintain anthracnose
- Fungicides applied in time interval between flower emergence and fruit setting found successful to control anthracnose
- In prior to other protective fungicides, it was found that benomyl with a surfactant provide excellent control over the Colletotrichum species (Meah and Khan., 1987)

Post-harvest Management

- Post-harvest infections are primarily managed using chemical fungicides.
- Eco-friendly management has become more popular as a chemical substitute.
- Hot water dip treatment is a post-harvest treatment for the control of anthracnose. It was found effective at a temperature of 55-60 degree Celsius. Jabba *et al.*, 2011 reported that the hot water treatment reduces the anthracnose and found as a control against disease.The temperature chosen for HWT offers great promise for reducing postharvest losses of different fruits because it is marginally higher than the target pathogen's thermal death point. Most of the pathogen's proteins and enzymes are denatured and the pathogen is usually destroyed at high temperatures.

Emerging Technologies for anthracnose Control

In an effort to effectively control the anthracnose disease that affects perishable fruits, some innovative or cutting-edge solutions have come under investigation recently. These, including the use of edible coatings, biological control, natural inducers, sanitizers, essential oils and substances that are widely recognized as safe.

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ROLE OF NATURAL FARMING IN ENVIRONMENTAL CONSERVATION AND ITS FUTURE PERSPECTIVES

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Introduction

Natural farming, also known as sustainable agriculture or regenerative agriculture, is an approach to farming that seeks to work in harmony with nature rather than against it. The goal of natural farming is to cultivate crops and raise livestock in a way that replenishes the soil, promotes biodiversity, conserves water, and minimizes the use of synthetic inputs such as pesticides and fertilizers. Natural farming holds profound significance in addressing pressing global challenges related to agriculture, environment, and human well-being. At its core, natural farming offers a holistic approach to agriculture that prioritizes sustainability, biodiversity conservation, and resilience. By embracing practices that work in harmony with natural ecosystems, natural farming stands as a beacon of hope in a world grappling with issues such as climate change, food insecurity, and ecological degradation.

The key principles and practices of natural farming are,

- **Soil Health:** Natural farming emphasizes the importance of soil health as the foundation of agriculture. Practices such as cover cropping, crop rotation, and composting are used to build soil fertility, structure, and microbial diversity.
- **Minimal Tillage:** Tillage is minimized or eliminated to prevent soil erosion, preserve soil structure, and maintain soil moisture. No-till or reduced-till methods are employed to disturb the soil as little as possible.
- **Crop Diversity:** Natural farming promotes the cultivation of a diverse range of crops, including both cash crops and cover crops. Crop diversity helps to prevent pest and disease outbreaks, improve soil health, and support beneficial insects and wildlife.
- **Integrated Pest Management (IPM):** Rather than relying on synthetic pesticides, natural farming emphasizes the use of integrated pest management techniques such as crop rotation, habitat manipulation, biological control, and the use of natural predators and parasites to manage pests and diseases.
- **Organic Inputs:** Natural farming avoids the use of synthetic fertilizers and pesticides, opting instead for organic inputs such as compost, manure, green manure, and natural amendments like rock dust and biochar.
- **Water Conservation:** Water conservation is a key aspect of natural farming. Techniques such as mulching, drip irrigation, rainwater harvesting, and contour farming are used to minimize water use and prevent soil erosion.
- **Agroforestry:** Agroforestry practices, such as alley cropping, windbreaks, and forest farming, are often integrated into natural farming systems to increase biodiversity, improve soil health, and provide additional sources of income.
- **Livestock Integration:** Livestock are integrated into natural farming systems in a way that mimics natural ecosystems. Managed grazing, rotational grazing, and silvopasture are used to improve soil fertility, control weeds, and reduce the environmental impact of livestock production.
- **Community Engagement:** Natural farming often involves community engagement and collaboration, with farmers sharing knowledge, resources, and best practices to support each other and promote sustainable agriculture at the local level.

One of the most critical aspects of natural farming is its emphasis o n soil health. Healthy soils are the foundation of productive and sustainable agriculture, yet conventional farming practices often degrade soil quality through erosion, compaction, and chemical contamination. Natural farming, on the other hand, focuses on building soil fertility, structure, and microbial diversity through techniques such as cover cropping, composting, and minimal tillage. By nurturing healthy soils, natural farming not only supports crop productivity but also enhances ecosystem resilience and carbon sequestration, contributing to climate change mitigation efforts.

Moreover, natural farming reduces reliance on synthetic inputs such as pesticides and fertilizers, which can have detrimental effects on human health, wildlife, and the environment. By promoting organic farming methods, biological pest control, and nutrient cycling, natural farming minimizes chemical pollution and promotes a safer and healthier food system. This shift towards more ecologically friendly farming practices not only benefits farmers and consumers but also contributes to the conservation of water resources, reduction of greenhouse gas emissions, and protection of aquatic and terrestrial ecosystems.

Future Perspectives of Natural Farming

The natural farming is a holistic approach to agriculture that recognizes the interconnectedness of soil, plants, animals, and people, and seeks to create farming systems that are environmentally sustainable, socially equitable, and economically viable in the long term. The future of natural farming holds significant promise and potential, driven by several key trends and developments. the future of natural farming is promising, driven by increasing awareness, technological innovation, policy support, consumer demand, research, and collaboration. By adopting and scaling up natural farming practices, farmers can contribute to more sustainable, resilient, and equitable food systems that benefit both people and the planet.

Increased Awareness and Adoption:

As concerns about environmental sustainability, climate change, and food security continue to grow, there is increasing awareness and interest in natural farming practices. Farmers, consumers, policymakers, and researchers are recognizing the benefits of natural farming for soil health, biodiversity conservation, water conservation, and resilience to climate change.

Technological Innovation

Advances in technology, such as precision agriculture, sensor technology, drones, and remote sensing, are being increasingly integrated into natural farming practices. These technologies enable farmers to monitor soil health, manage crops more efficiently, optimize water use, and reduce environmental impact.

Regenerative Agriculture Movement:

The regenerative agriculture movement, which encompasses natural farming principles, is gaining momentum globally. Farmers, companies, and organizations are adopting regenerative practices to restore degraded lands, sequester carbon in soils, and mitigate climate change while producing healthy food.

Policy Support:

Governments and international organizations are increasingly recognizing the importance of sustainable agriculture and providing policy support for natural farming practices. Subsidies, incentives, and regulations that promote agroecology, organic farming, and regenerative agriculture are being implemented to encourage farmers to adopt more sustainable practices.

Consumer Demand:

Consumer demand for organic, sustainably produced food is growing, driving market demand for products from natural farming systems. Retailers, food companies, and restaurants are responding to this demand by sourcing ingredients from farms that use natural farming practices, thus creating economic incentives for farmers to adopt these methods.

Research and Education:

Continued research and education in the field of natural farming are essential for further innovation and improvement. Universities, research institutions, and agricultural extension services are conducting research on natural farming techniques, developing best practices, and providing training and support to farmers.

Climate Resilience:

Natural farming practices, such as agroforestry, cover cropping, and soil carbon sequestration, can enhance the resilience of agricultural systems to climate change. By improving soil health, conserving water, and increasing biodiversity, natural farming helps farmers adapt to changing environmental conditions and mitigate the impacts of extreme weather events.

Global Collaboration

Collaboration and knowledge sharing among farmers, scientists, policymakers, and organizations at the local, national, and international levels are essential for scaling up natural farming practices and addressing global challenges such as food insecurity, environmental degradation, and climate change.

Natural farming holds significant potential for ecological conservation by promoting farming practices that work in harmony with natural ecosystems rather than depleting or degrading them. Natural farming offers holistic solutions for ecological conservation by promoting farming practices that regenerate soils, enhance biodiversity, conserve water, sequester carbon, and support resilient ecosystems. By embracing the principles of natural farming, farmers and communities can play a vital role in safeguarding the health and integrity of the natural world for future generations.

CONTRIBUTION OF NATURAL FARMING IN ECOLOGICAL CONSERVATION

Furthermore, natural farming promotes biodiversity conservation on farmland, recognizing the interconnectedness of plants, animals, and microorganisms in agricultural ecosystems. Through practices such as crop diversification, agroforestry, and habitat restoration, natural farming creates habitats for beneficial insects, birds, and wildlife, fostering ecosystem balance and resilience. By preserving and enhancing biodiversity, natural farming helps to safeguard essential ecosystem services such as pollination, pest control, and soil fertility, which are vital for agricultural productivity and environmental sustainability.

Biodiversity Enhancement

Natural farming encourages the preservation and enhancement of biodiversity on farmland. By cultivating a diverse range of crops, incorporating hedgerows, windbreaks, and buffer strips, and creating habitat for beneficial insects and wildlife, natural farming systems can support a wide array of plant and animal species, contributing to overall ecosystem resilience and stability.

Reduced Chemical Inputs:

Natural farming minimizes or eliminates the use of synthetic pesticides and fertilizers, which can have detrimental effects on ecosystems and non-target organisms. By relying on organic inputs, biological pest control methods, and cultural practices to manage pests and diseases, natural farming reduces chemical pollution and promotes a healthier environment for both agricultural and wild species.

Water Conservation:

Natural farming practices such as mulching, drip irrigation, and soil conservation techniques help conserve water resources and reduce the risk of water pollution from agricultural runoff. By minimizing soil erosion and improving water infiltration and retention, natural farming contributes to the health of aquatic ecosystems and freshwater habitats.

Carbon Sequestration:

Natural farming has the potential to sequester carbon in soils, helping to mitigate climate change by removing carbon dioxide from the atmosphere and storing it in organic matter. Practices such as cover cropping, agroforestry, and no-till farming enhance soil organic carbon levels, providing long-term benefits for soil fertility, water retention, and climate resilience.

Habitat Connectivity:

Natural farming landscapes can serve as corridors and refuges for wildlife, promoting habitat connectivity and biodiversity conservation across larger spatial scales. By maintaining or restoring natural habitats within agricultural landscapes, natural farming contributes to the conservation of native species and ecological processes, supporting ecosystem functioning and resilience.

In conclusion, natural farming offers a compelling vision for the future of agriculture one that is rooted in ecological principles, social justice, and resilience. By embracing natural farming practices, we can cultivate a more sustainable, equitable, and harmonious relationship with the natural world, ensuring the well-being of current and future generations. In addition to its environmental benefits, natural farming holds social significance by promoting equitable and resilient food systems. By empowering farmers with knowledge and skills to adopt sustainable agricultural practices, natural farming fosters community resilience, food sovereignty, and rural development. Furthermore, by prioritizing local food production, agroecological knowledge, and traditional farming practices, natural farming strengthens cultural identity and food security, particularly in marginalized and vulnerable communities.

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PROMISING SORGHUM VARIETIES AND HYBRIDS FOR CULTIVATION IN INDIA

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Introduction

Sorghum is predominantly cultivated by subsistence farmers in the semi-arid regions of Africa, Asia, and Latin America. It is a crucial staple food crop in these semi-arid areas, providing essential energy, proteins, vitamins, and minerals for millions of underserved people in these regions. Conversely, it serves as animal feed in the Americas, China, and Australia. India is the sixth largest producer of Sorghum in the world, with an annual production of 4.4 million metric tonnes. In India sorghum is largely cultivated in Maharashtra (37%), Karnataka (22%), Tamil Nadu (10%), Rajasthan (8%), Madhya Pradesh (7%), Uttar Pradesh (6%), Andhra Pradesh (6%) and Telangana (2.65 %) (IPDA, 2023). Sorghum is adapted to wide range of ecological conditions, especially hot and warm regions, tolerating hot and dry conditions as well as high rainfall leading to water logging. This crop thrives in harsh environments where other crops struggle to grow. The majority of the produce is consumed locally, and surpluses often lack price stability.

1. Grain Sorghum Varieties

CSV 1: A duration of 95-100 days, with grain yield of 3000-5000 kg/ha. It is suitable for Kharif Sorghum growing areas of Maharastra, Gujarat, Karnataka and Andra Pradesh.

CSV 2: A duration of 105-110 days, with grain yield of 3000-3500 kg/ha. Suitable for Kharif Sorghum growing areas of Maharastra, Madhya Pradesh, Rajasthan, Bundlekhand of Uttar Pradesh and Noth Telangana.

CSV 3: A duration of 105-110 days, with grain yield of 3000-4000 kg/ha. Suitable for all Kharif Sorghum growing areas of the country.

CSV 4: A duration of 105-110 days, with grain yield of 3000-3500 kg/ha. Suitable for all Kharif Sorghum growing areas of the country.

CSV 5: A duration of 110-120 days, with grain yield of 3000-3500 kg/ha. Suitable for Karnataka, Tamil Nadu and Maharastra.

CSV 6: A duration of 115-120 days, with grain yield of 3200-3500 kg/ha. Suitable for rainfed areas of Vidharbha, West Maharastra, Madhya Pradesh, Kota regions of Rajasthan, Bundelkhand of Utar Pradesh, South Gujarat, Adilabad ofAndra Pradesh and Tamil Nadu.

CSV 31: CSV 31 is recommended for rainfed conditions in the Kharif season in Andhra Pradesh, Tamil Nadu, Rajasthan, and Gujarat. It stands at a height ranging from 210-250 cm and features juicy stems, a white colour mid-rib, waxy bloom, semi-compact symmetric panicle, pearly white seeds, and grey-yellow endosperm. It's also known for its tolerance to grain mold and resistance to anthracnose and leaf blight.

Paiyur 1: Paiyur 1 is suitable for the northeast and north western districts of Tamil Nadu. It has a duration of 145-150 days and features juicy stalks with a height of 300 cm. The sheath colour is green, the midrib is white, and the earhead is a lax panicle with open compactness. The grain colour is pearly white. Importantly, it's tolerant to drought, non-lodging, and is photosensitive.

K Tall: This variety is recommended for the southern districts in Tamil Nadu. It has duration of 90 days and features juicy stalks with a height of 254 cm. The sheath colour is brown, the midrib is dull white, and the earhead is compact with lanceolate semi-open compactness. The grain colour is cream pearly.

K 11: K 11 is suitable for the southern districts in Tamil Nadu. It has duration of 110-115 days and features thin, juicy, and sweet stalks with a height ranging from 220-260 cm. The sheath colour is reddish-purple at maturity, the midrib is dull white, and the earhead is erect with a loose panicle.

2. Grain Sorghum Hybrids

CSH 2: A duration of 115-120 days, with a grain yield of 3000-3500 kg/ha. It is suitable for assured rainfall mid-late kharif tracts, specifically in Karnataka.

CSH 3: A duration of 150-170 days, with a grain yield of 3500-3800 kg/ha. Suitable for rainfed tracts in Maharastra, Telangana and monsoon areas of Tamil Nadu, Malwa Plateau of Madhya Pradesh and Bundelkhand of Uttar Pradesh.

CSH 4: A duration of 105-110 days, with a grain yield of 3500-3800 kg/ha. Suitable for all kharif and some rabi areas of all over India.

CSH 26: Recommended for cultivation in Maharashtra, Karnataka, MP, South Gujarat, and North AP & TN. It's a Kharif Hybrid with a height of 205 cm, characterized by a white midrib colour, semi-erect leaves, and a semi-compact panicle. It exhibits tolerance to Charcoal rot, Ergot, Rust, shoot fly, aphids, and stem borer.

CSH 27: This Kharif Hybrid is suitable for Rajasthan, North Gujarat, UP, AP, and Tamil Nadu. It shares a similar height of 205 cm and features a tan plant colour with a cylindrical semi-compact panicle and white bold elliptical seed. It belongs to the medium maturity group and displays tolerance to grain mold disease under natural conditions.

CSH 28: Recommended for Maharashtra, Karnataka, MP, South Gujarat, and North Andhra Pradesh. It falls in the medium-tall category with medium maturity. Known for its long bold panicle and bold grains, it is tolerant to shoot fly and grain mold. It also exhibits high grain and fodder yields with a strong response to nitrogen fertiliser.

CSH 29: Suitable for Maharashtra, Karnataka, MP, South Gujarat, and North AP, a Kharif Hybrid with a height of 220 cm. It features a white midrib colour, semi-erect leaves, semi-compact panicle, and lustrous grain. This hybrid has medium maturity and is resistant to foliar diseases, and is moderately resistant to grain mold.

CSH 30: Designed for regions like Maharashtra, Karnataka, MP, South Gujarat, and North AP under rainfed Kharif cultivation, Resistant to lodging and non-shattering. It has a tan plant colour, 216 cm height, symmetric semi-compact panicle, and white bold elliptical seed.

CSH 31R: This hybrid is recommended for all rabi sorghum growing states of India. It's a Rabi hybrid known for its high grain yield and fodder yield. Tolerant of drought, making it a valuable choice for regions with water constraints.

CSH 32: Tailored for Maharashtra, Karnataka, MP, South Gujarat, and North AP, a Kharif hybrid with a height of 221 cm. It exhibits a white midrib colour, semi-erect leaves, semi-compact panicle, and tolerance to Charcoal rot, Ergot, Rust, shoot fly, aphids, and stem borer. It's non-lodging and non-shattering, making it highly responsive for deep soils.

CSH 33: Suited for Rajasthan, UP, North Gujarat, South Andhra Pradesh & TN, CSH 33 is a Kharif hybrid with a height of 185 cm and early maturity. It features a well-exerted compact panicle and medium bold grain. Additionally, it's tolerant to significant pests and diseases.

CSH 34: Designed for Maharashtra, Karnataka, MP, AP, Chattisgarh Gujarat, and Rajasthan, a Kharif hybrid with a height of 210 cm. It possesses medium maturity, semi-compact earhead, awnless attributes, and resistance to downy mildew. It's notable for escaping grain mold due to slightly longer maturity duration.

CSH 35: Recommended for Maharashtra, Karnataka, MP, South Gujarat, and Telangana, a Kharif hybrid with a height of 215 cm. It features medium maturity, an oblong earhead with tapering apex, internodes covered by leaf sheath, dull green midrib, and tolerance to significant pests and diseases.

COH 4: This hybrid variety is recommended for all districts in Tamil Nadu with a duration of 105-110 days. It features juicy stalks, a height of 200-215 cm, a green sheath colour, and a white midrib. The earhead is elliptic and semi-compact, with a pearly white grain colour. Additionally, it's known for its lower incidence of leaf diseases, grain mold, and sugary diseases.

3. Forage Sorghum varieties

CSV 30F: It is specifically suited for all forage sorghum growing areas of India. It's categorized as a forage sorghum variety, with occasional gooseneck tendencies in the panicle due to environmental fluctuations. It gives a grain yield of 4300-4600 kg/ha and a fodder yield of 13000-15000 kg/ha. It has a juicy stem with white midrib, semi-loose oval panicle. It is tolerant to shoot fly and stem borer.

CSV 32F: Designed for all forage sorghum growing areas of Maharashtra, Tamil Nadu, and Karnataka.

CSV 33MF: This forage sorghum variety is recommended for all forage sorghum growing states in Zone 1 and II. It features a tall and thin stem with high tillering. The first cut is typically done after 62 days, followed by subsequent cuts after 50 days. It boasts a green fodder yield of 1039 q/ha and a dry fodder yield of 280 q/ha. It is resistant to leaf blight and anthracnose.

CSV 35F: Single-cut High fodder yield (650-750 q/ha green and 175-200 q/ha dry). It has very high protein content (8.38) and high digestibility (53.71%). Resistance to foliar disease stays green quality and red colour grain.

CSV 32F: Yielded 463 q/ha of green fodder and 178 q/ha of dry fodder with about 20% improvement over CSV 21F. Suited to all forage growing areas of Maharastra, Tamil Nadu and Karnataka.

CSV 33MF recorded a green fodder yield of 1040 q/ha and a dry fodder yield of 280.57 q/ha out of three cuts. Its protein yield is 25.57q/ha and possesses high tillering (5-7) and a good renewability score (4.17). HCN content is 63.07 ppm, which is well below the safe limits.

Co 27: A fodder Sorghum variety having a crop duration of 60-65 days. It gives a fodder yield of 35-40 t/ha. It has thin stem and tolerant to drought.

Co FS. 29: It is a multi-cut variety released by TNAU in 2001. It is a cross between TNFS 9602 and Sudan grass. It gives a fodder yield of 170 t/ha in 6-7 cuttings. It produces more tiller and is ratoonable with quick regeneration and moderately tolerant to drought.

Co 31: It is a multi-cut fodder sorghum, yielding 190 t/ha in 6-7 cuttings. It is moderately tolerant to drought.

4. Forage Sorghum hybrids

CSH 24MF: It is a multi-cut fodder sorghum hybrid yielding 7.88 t/ha in 6-7 cuttings. It is recommended for kharif season of Andra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Rajasthan, Maharastra and Tamil Nadu. It gives a grain yield of 7880 kg/ha and fodder yield of 19800 kg/ha.

CSH 40F: Single-cut Average yield of 700-900 q/ha green fodder and 200-275 q/ha dry fodder. Low HCN content (92.42ppm), High protein content (8.39), high digestibility (53.46%).

TNAU Sorghum Hybrid CO 5: This hybrid is suitable for all districts in Tamil Nadu. It has duration of 95-105 days and features juicy stalks, a height of 210-230 cm, and a tan sheath colour. The earhead is cylindrical and semi-loose with an elliptical grain colour in pearly white. It possesses moderately high dry matter digestibility and tolerance to shoot fly and grain mold.

5. Dual purpose Sorghum varieties

CSV 9: A duration of 110-115 days, with grain yield of 3000-3500 kg/ha and fodder yield of 8940 kg/ha. It is suitable for all Kharif Sorghum growing areas of the country.

CSV 10: A duration of 110-115 days, with grain yield of 3000-3500 kg/ha and fodder yield of 9010 kg/ha. Suitable for Maharastra, Karnataka, Andra Pradesh and Rajasthan.

CSV 11: A duration of 110-115 days, with grain yield of 3250 kg/ha and fodder yield of 9600 kg/ha. It is suitable for all kharif growing areas in India.

CSV 13: A duration of 110-120 days, with grain yield of 3525 kg/ha and fodder yield of 9700 kg/ha. It is suitable for all kharif growing areas in India.

CSV 15: A duration of 110-112 days, with grain yield of 3621 kg/ha and fodder yield of 12100 kg/ha. It is suitable for all kharif growing areas in India.

CSV 17: It has **a** duration of 97 days, with grain yield of 2500 kg/ha and fodder yield of 6800 kg/ha. It is suitable for low rainfall and drought prone Sorghum growing regions in India.

CSV 22: It is **s**uited to rabi season of Maharastra, Karnataka, Andra Pradesh, Gujarat and Tamil Nadu under rainfed condition. It gives a grain yield of 2300 kg/ha and fodder yield of 7100 kg/ha. It had a white midrib, semi-compact and lodging property.

CSV 23: It is suitable for kharif season of Sorghum growing states of India. It has a maturity duration of 113 days. It gives a grain yield of 2800 kg/ha and a fodder yield of 15500 kg/ha. It give a quality fodder and reistant to gerain mold, rust, anthracnose and Zonate leaf spot.

CSV 26R: It is suitable for shallow soils, during Rabi seasons of India. It gives a grain yield of 1029 kg/ha and fodder yield of 4244 kg/ha. It is superior in nutritional alue and for roti quality. It's foliage is clean, stay-green and it is a non-lodging variety.

CSV 27: Suited to all kharif Sorghum growing rainfed areas of India. It gives a grain yield of 2800 kg/ha and a fodder yield of 19300 kg/ha. It is a stay-green sorghum variety having tolerance to grain mold.

CSV 28: Suited to all kharif Sorghum growing areas of India. It gives a grain yield of 2827 kg/ha and a fodder yield of 17304 kg/ha. It is a stay-green sorghum variety having tolerance to grain mold and it is a non-lodging variety.

CSV 29R: Suited for Rabi season of Maharastra, Karnataka and Andra Pradesh. It gives a grain yield of 2553 kg/ha and a fodder yield of 6791 kg/ha. It is resistant to shoot fly and Charcoal rot diseases.

6. Dual purpose Sorghum hybrids

CSH 1: A duration of 90-100 days with grain yield of 300-3500 kg/ha and fodder yield of 7500 kg/ha. Suitable to Tamil Nadu, Andra Pradesh, Karnataka, Rajasthan, Uttar Pradesh, Gujarat, Maharastra, Madhya Pradesh, specifically adopted to low rainfall and light soil kharif areas of the country.

CSH 5: A duration of 100-120 days, with a grain yield of 3800-4000 kg/ha and fodder yield of 9300 kg/ha. Suitable for all kharif and late khharif tracts ofAndra Pradesh and summer irrigatedvareas in Tamil Nadu and Karnataka. Well adopted for intercropping and rationing.

CSH 6: A duration of 95-100 days, with a grain yield of 3376 kg/ha and fodder yield of 8100 kg/ha. Suitable for cultivation in kharif, early rabi and rabi seasons all over India. Suitable for low rainfall tracts of kharif and late kharif seasons in Andra Pradesh. Ideally suitable for intercropping and ratooning.

CSH 9: A duration of 105-110 days, with a grain yield of 4000-4200 kg/ha and fodder yield of 9800 kg/ha. It is suitable for all kharif Sorghum growing areas except in humid areas of Karnataka and Tamil Nadu.

CSH 10: A duration of 100-115 days, with a grain yield of 3633 kg/ha and fodder yield of 12000 kg/ha. It is suitable for Karnataka state.

CSH 11: A duration of 105-115 days, with a grain yield of 4172 kg/ha and fodder yield of 9180 kg/ha. It is suitable for all kharif growing areas of the country.

CSH 13: A duration of 105-110 days, with a grain yield of 3924 kg/ha and fodder yield of 14100 kg/ha. It is suitable for Andra Pradesh, Gujarat, Tamil Nadu, Karnataka, Madhya Pradesh, Haryana, Rajasthan, Maharastra and Uttar Pradesh.

CSH 14: A duration of 105 days, with a grain yield of 3840 kg/ha and fodder yield of 8800 kg/ha. It is suitable for all kharif growing areas of the country. Also suited to medium to heavy soils for low rainfall areas.

CSH 16: A duration of 110 days, with a grain yield of 4308 kg/ha and fodder yield of 9676 kg/ha. It is suitable for kharif growing areas of Maharastra, Tamil Nadu, Andra Pradesh, Gujarat, Karataka, Madhya Pradesh, Rajasthan and Uttar Pradesh.

CSH 17: A duration of 103 days, with a grain yield of 4186 kg/ha and fodder yield of 10400 kg/ha. Suitable for all kharif growing areas of Tamil Nadu, Gujarat, Madhya Pradesh, and Rajasthan.

CSH 18: A duration of 110-115 days, with a grain yield of 4336 kg/ha and fodder yield of 13100 kg/ha. It is suitable for all kharif season as a rainfed crop in Sorghum growing states in the country.

CSH 23: A duration of 105 days, with a grain yield of 4100 kg/ha and fodder yield of 8700 kg/ha. Suitable for all over India.

CSH 25: A duration of 110-115 days, with a grain yield of 4370 kg/ha and fodder yield of 12710 kg/ha. It is suitable for Kharif season of India. It produces pearly white grains and it is tolerant to grain mold and shoot fly.

CSH 27: Dual purpose Sorghum giving a grain yield of 3922 kg/ha and fodder yield of 13600 kg/ha. It is resistant to grain mold.

CSH 30: Dual purpose Sorghum, giving a grain yield of 2500 kg/ha and fodder yield of 7500 kg/ha.

Co 26: This variety is recommended for all districts in Tamil Nadu with a duration of 105-110 days. It features juicy and sweet stalks, with a height ranging from 160-190 cm. It has a green sheath colour, a dull white midrib, and a long cylindrical earhead with semi-compact grain. The grain colour is pearly white.

Co (S) 28: Suitable for all districts in Tamil Nadu, Sorghum CO (S) 28 has a duration of 100-105 days. It features juicy stalks, a height of 220-240 cm, a tan sheath colour, and a dull white midrib. The earhead is cylindrical and semi-compact, with white grain colour. It's known for its lower incidence of leaf diseases, grain mold and sugary diseases.

TNAU Sorghum CO 30: Suitable for all districts in Tamil Nadu, TNAU Sorghum CO 30 has duration of 95-105 days. It exhibits features such as juicy stalks, a height of 220-240 cm, a tan sheath colour, and a dull white midrib. The earhead is cylindrical and semi-compact, and the grain colour is white. Notably, it possesses moderately high dry matter digestibility and tolerance to shoot flies, grain mold, and downy mildew.

BSR 1: Multiple cross derivative of (SC 108-3 x ICSV 4) 16-3-1 x (MR-801 x R 2751)4-1-1. It has duration of 105-110 days, suitable for Coimbatore, Erode, Salem, Trichirapalli, Perambalur, Karur and Dindigul districts of Tamil Nadu. It has a grain yield of 6000-6500 kg/ha and fodder yield of 9600 kg/ha under irrigated condition and gain yield of 2500-3500 kg/ha and fodder yield of 8600 kg/ha under rainfed condition. It produces pearly white grains, fertilizer responsive and resistant to earhead bug, shoot fly and stem borer.

Paiyur 2: Pureline selection from IS 15845, having duration of 90-95 days. It is suitable for rainfed condition during Puratasi season of Salem and Namakkal districts of Tamil Nadu. It gives a grain yield of 2113 kg/ha and a fodder yield of 8789 kg/ha under rainfed condition. It is a dual purpose red grained sorghum, having tolerance to downy mildew and Charcoal rot diseases.

APK 1: An hybrid derivative of TNA 30 x Co 26> It is having a duration of 105-110 days, suited to rainfed conditions during Adi and Puratasi season of Southern districts of Tamil Nadu.

It is gives a grain yield of 2619 kg/ha and fodder yield of 8090 kg/ha. It produce white grains in a semi-compact panicle. It is a non-lodging variety.

7. Sweet Sorghum varieties

CSV 24SS: A Sweet Sorghum variety suitable for all Sorghum growing areas of India released in 2011. It has maturity duration of 120 days. It gives a cane yield of 3.91 t/ha giving a juice yield of 14833 l/ha. It has a long and broad leaves with yellow green midrib and a loose open panicle.

SSV 84: A selection from IS 23568, having a duration of 120-125 days suitable to kharif season of India. It gives a grain yield of 1000-1200 kg/ha, cane yield of 30-35 t/ha and ethanol yield of 800-1000 Kl/ha.

RSSV 9: A cross derivative of RSSV x SPV 462. It has maturity duration of 115-120 days. It is suitable to kharif season of India. It gives a grain yield of 800-1000 kg/ha, cane yield of 35-40 t/ha and ethanol yield of 1000-1200 Kl/ha.

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PROTEIN QUALITY OF MILLETS COMPARED WITH WHEAT AND RICE

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ABSTRACT

Millets are rich in fibre, protein, vitamins, minerals and antioxidants than the three major cereals *viz*., rice, wheat and maize. Based on protein per cent, only two millets *viz*., Proso millet and Foxtail millet exceeded the protein content of wheat and are recorded as the better source of protein than wheat. The high protein content of all millets, except Barnyard millet indicate the superiority of these millets over rice. Further wheat has a type of protein called Gluten, which may create sensitivity to individuals having Celiac diseases. Further all millets as well as rice is free of this gluten protein. So, all our millets can be a substitute for gluten sensitive foods. For protein digestibility, six millets *viz*., Proso millet, Little millet, Kodo millet, Barnyard millet, Foxtail millet and Pearl millet excelled far better than wheat and rice. Among the eight millets taken for discussion, only Finger millet have high Protein efficiency ratio higher than rice and wheat. All millets scored higher or on par protein efficiency ratio with wheat. Though rice have the least protein content, its protein biological value (63.10 is of the highest level than wheat and all millets. On comparison with PBV of wheat, it is understood that all millets except Sorghum have high or on par PBV than wheat. similar to rice and wheat three millets *viz*., Sorghum, Pearl millet and Finger millet have complete protein and are equivalent to rice and wheat proteins.

Barnyard millet, Kodo millet and Proso millet has one (Tryptophan) limiting amino acid. Further, similar to Rice and Wheat, Sorghum and Little millet has two limiting amino acids (Tryptophan and Cystine). Regarding Excess essential amino acids, Finger millet alone is superior than rice, followed by Foxtail, Barnyard, Proso and Little millets that are considered equivalent to rice. When compared wuth wheat for Excess essential amino acids, Sorghum, Pearl millet and Kodo millet are better than Wheat and all other millets far better than wheat. Based on overall total score for protein quality attributes, none of the millets are inferior to Wheat, but Finger millet and Pearl millet scored higher than Wheat as well as Rice.

Key words: Millets Protein quality, Protein digestibility, Protein biological value, Protein efficiency ratio

Introduction

Millets are highly nutritious than fine grain cereals such as rice and wheat. They are also called nutri-cereals due to their high nutritional value. Millets are rich in fibre, protein, vitamins, minerals and antioxidants than the three major cereals *viz*., rice, wheat and maize. Protein is one of the major nutrients that our body needs to grow and repair cells and to work properly. Proteins are the building blocks of body tissue and can also serve as a fuel source. Proteins provide 4 kcal (17 kJ) per gram as like Carbohydrates, in contrast to lipd that provide 9 kcal (37 kJ) per gram. Proteins are composed of amino acids that are classified into essential and non-essential amino acids. Millets contain most of the essential amino acids that make them a complete protein as similar to major cereals. For example Sorghum, Pearl millet and Finger millet grains contain all 12 essential amino acids, while Foxtail millet, Barnyard millet, Proso millet and Little millet (all except Tyrosine), and Kodo millet (all except cysteine) are deficit for only one essential amino acid. All millets are gluten free and hence act as a substitute diet for persons with Celiac disease, the condition of intolerance to gluten protein.

1. Protein content:

Higher protein content than wheat (11.8%) were found in Proso millet (12.5%) and Foxtail millet (12.3%), and higher protein content than rice (6.8%) were found in Pearl millet (11.6%), Sorghum (10.4%), Kodo millet (8.3%), Little millet (7.7%), and Finger millet (7.3%). Only Barnyard millet (6.2%) scored lesser and least protein content than rice and other millets. Hence, based on protein per cent, only two millets *viz*., Proso millet and Foxtail millet exceeded the protein content of wheat and are recorded as the better source of protein than wheat. Further wheat has a type of protein called Gluten, which may create sensitivity to individuals having Celiac diseases. Further all millets as well as rice is free of this gluten protein. So, all our millets can be a substitute for gluten sensitive foods.

Considering the protein content of Rice (6.80 per cent), which the least but one that of Barnyard millet (6.20 per cent) all other millets have higher protein content than rice. The two millets *viz*., Proso millet and Foxtail millet have approximately double the quantity of protein than rice. The high protein content of all millets, except Barnyard millet indicate the superiority of these millets over rice. Therefore, taking millet as a substitute food in the place of rice is worthy decision based on protein content.

2. Protein Digestibility per cent (PDP):

It is defined as how well a given protein is digested. Along with the amino acid score, protein digestibility determines the values for Protein Digestibility Corrected Amino Acid Score (PDCAAS) value (Devi et al., 2018). Higher per cent of Protein digestibility is an indication of protein quality that a food protein gets easily digested and gets assimilated in the body. Higher protein digestibility per cent was noticed for Proso millet (99.30 per cent), followed by Little millet (97.70 per cent), Kodo millet (96.60 per cent), Barnyard millet (95.30 per cent), Foxtail millet (95.00 per cent) and Pearl millet (94.60 per cent). All these six millets have scored very high protein digestibility per cent and it is much higher than rice (66.00 per cent) and higher than wheat (81.00 per cent).

Table 1. Protein quality parameters of different millets as compared to rice and wheat

Millets	[1]PCP	[2]PDP	[2]PER	[2]PBV	[1]AEA	[1]LEA	[1]EEA
Sorghum	10.40	46.00	0.74	37.00	Nil	Tryptophan & Cystine	Leucine & Valine
Pearl millet	11.60	94.60	1.60	58.80	Nil	Nil	Leucine, Valine & Arginine
Finger millet	7.30	76.00	2.00	52.00	Nil	Nil	Leucine, Isoleucine, Valine, Phenyl Alanine & Arginine
Foxtail millet	12.30	95.00	0.80	48.40	Tyrosine	Tryptophan	Leucine, Isoleucine, Valine, & Phenyl Alanine
Barnyard millet	6.20	95.30	0.95	54.80	Tyrosine	Tryptophan	Leucine, Phenyl Alanine, Valine & Isoleucine

Kodo millet	8.30	96.60	0.90	56.50	Cystine	Tryptophan	Glutamic acid, Leucine & Phenyl Alanine
Proso millet	12.50	99.30	1.10	52.40	Tyrosine & Cystine	Tryptophan	Leucine, Isoleucine, Valine, & Phenyl Alanine
Little millet	7.70	97.70	0.90	53.00	Tyrosine	Tryptophan & Cystine	Leucine, Isoleucine, Valine, & Phenyl Alanine
Rice	6.80	66.00	1.67	63.10	Nil	Tryptophan & Cystine	Leucine, Valine, Isoleucine & Arginine
Wheat	11.80	81.00	0.79	49.10	Nil	Tryptophan & Methionine	Leucine

PCP-Protein content per cent; **PER**- Protein Efficiency Ratio; **PDP**- Protein Digestibility per cent; **PBV**-Protein Biological Value in per cent; **AEA**-Absent Essential Amino Acid; **LEA**-Limited Essential Amino Acid and **EEA**-Excess Essential Amino Acid.
Sources: 1- Sorghum and millet in human nutrition, FAO, 1995 and Amaduo et al., 2013; 2-Singh et al., 1987 and Geervani and Eggum, 1989.

On comparing with the protein digestibility of rice, all millets except Sorghum had higher protein digestibility per cent than rice. Among the millets, only Sorghum (46.00 per cent) followed by Finger millet (76.00 per cent) have the least Protein digestibility. However, Finger millet have better digestibility than rice. Considering wheat and rice, six millets *viz*., Proso millet, Little millet, Kodo millet, Barnyard millet, Foxtail millet and Pearl millet excelled far better than wheat and rice.

3. Protein Efficiency ratio (PER):

This is based on the weight gain of a test subject to the intake of a particular food protein during the test period. The protein efficiency ratio had been widely used as a method for evaluating the quality of protein in food. Higher the PER value of the protein, the more beneficial it is to the test subject (FAO, 1991). Though protein digestibility be on the higher side, it is the Protein efficiency ratio that accounts for final utility value of a food product. A food that has higher Protein efficiency ratio is well digested and well assimilated and converted into body structural protein. Among the eight millets taken for discussion, only Finger millet have high Protein efficiency ratio of 2.00 that is higher than rice (1.67) and wheat (0.79). All millets scored higher or on par ratio with wheat. Therefore all the millets are superior to wheat in respect of

Protein digestible ratio. As of Protein digestibility per cent, Sorghum scored the least Protein efficiency ratio (0.74) among millets as well as rice and wheat.

4. Protein Biological value (PBV):

This is a measure of the proportion of absorbed protein from a food which becomes incorporated into the proteins of the organism's body (Mitchell, 1923). The protein biological value is yet another scoring of protein utilization quality. Though rice have the least protein content, its protein biological value (63.10 is of the highest level than wheat and all millets. On comparison with PBV of wheat, it is understood that all millets except Sorghum have high or on par PBV than wheat. Only Sorghum registered the least PBV than all millets as well as rice and wheat. Therefore, except Sorghum all millets are superior to wheat in PBV, but not with rice.

5. Essential Amino acids:

There are 20 different amino acids that are needed for our body to grow and function properly. Among them 11 are essential amino acids that are indispensable for body function but human body cannot synthesis from metabolic intermediates and must be supplied from an exogenous diet. This is because the human body lacks the metabolic pathways required to synthesis these amino acids (Michael et al., 2023). There are nine non-essential amino acids that that can be synthesised using the essential amino acids or it's related intermediates. Therefore, essential amino acids are conditionally essential for forming various body proteins, enzymes and hormones using essential as well as non-essential amino acids.

5.1. Absent Essential Amino acid (AEA):

A protein is called a complete protein when all essential amino acids are present in it. In this respect, as like rice and wheat, three millets *viz*. Sorghum, Pearl millet and Finger millet are considered to have a complete protein in them. Further, one essential amino acid is missing in Foxtail, Barnyard and Little millets (Tyrosine missing) as well as Kodo millet (Cystine missing), while two essential amino acids are missing in Proso millet (Tyrosine and Cystine missing). Hence, similar to rice and wheat three millets *viz*., Sorghum, Pearl millet and Finger millet have complete protein and are equivalent to rice and wheat proteins. Further, millets having absence of essential amino acids need to be supplemented with other food that complements the absent amino acids.

5.2. Limiting Essential Amino acid (LEA):

Although, all essential amino acids are represented in a complete protein, certain essential amino acids are being limited in their quantity or availability. These are called limiting amino acids. Considering this criterion, Rice has Tryptophan and cysteine and wheat has Tryptophan and Methionine as limiting amino acids. But among millets, Pearl millet and Finger millet has no limiting amino acids, while Foxtail millet, Barnyard millet, Kodo millet and Proso millet has one (Tryptophan) limiting amino acid. Further, similar to Rice and Wheat, Sorghum and Little millet has two limiting amino acids (Tryptophan and Cystine). As against wheat, none of the millets have methionine as limiting amino acid. Considering the presence or absence of limiting amino acids, Pearl millet and Finger millet are superior than rice as well as wheat and other millets. Further millets containing limiting amino acid, *viz*., Sorghum, Foxtail millet, Barnyard millet, Kodo millet, Proso millet and Little millet need to be supplemented with other type of foods that complement the limiting amino acids.

5.3. Excess Essential Amino acid (EEA):

Protein quality is also scored on the basis of number of excess essential amino acids. For example wheat protein has only one amino acid viz., Leucine as EEA, whereas Rice has four EEA (Leucine, Valine, Isoleucine and Arginine). Among the millets, Finger millet alone has five EEA (Leucine, Isoleucine, Valine, Phenyl Alanine and Arginine), while Foxtail, Barnyard and little millet has four EEA. Pearl millet and Kodo millet has only three EEA and Sorghum has two EEA. On comparing with rice, Finger millet alone is superior than rice, followed by Foxtail, Barnyard, Proso and Little millets that are considered equivalent to rice. Further all millets are better (Sorghum, Pearl millet and Kodo millet) or far better (all other millets) than wheat that has only one EEA.

6. Scoring for Protein quality in millets

Table 2. Scoring for Protein quality parameters of different millets as compared to rice and wheat (Based on Table 1 values)

Millets	PCP	PDP	PER	PBV	AEA	LEA	EEA	Total score
Sorghum	2	1	1	1	2	-2	2	09
Pearl millet	2	3	2	2	2	2	3	16
Finger millet	1	2	3	2	2	2	5	17
Foxtail millet	3	3	1	1	-1	-1	4	10

Barnyard millet	1	3	1	2	-1	-1	4	09
Kodo millet	1	3	1	2	-1	-1	3	08
Proso millet	3	3	2	2	-2	-1	4	11
Little millet	1	3	1	2	-1	-2	4	07
Rice	1	1	2	3	2	-2	4	11
Wheat	2	2	1	1	2	-2	1	07
Scores for PCP: 3- for > 12, 2- for > 10 to < 12, 1- for < 10. **Scores for PDP**: 3- for > 90%, 2- for >75 to <90 and 1- for < 75. **Scores for PER**: 3- for >2.0, 2- for <2.0 to 1.0 and 1 –for < 1.0. **Scores for PBV**: 3- for > 60, 2- for > 50.0 to < 60 and 1 – for < 50.0. **Scores for AEA**: 2-for Nil, -1-for 1absent and -2- for two absent. **Scores for LEA**: 2-for Nil, -1-for 1present and -2-for two present. **Scores for EEA**: A score value of 1 for each EEA.								

Based on the score value for different parameters of protein quality in millets (Table 2), the highest score was secured by Finger millet (17), followed by Pearl millet. These two millets secured higher protein quality score than Rice (11) and Wheat (07). Further, Proso millet (11) secured the same value as that of rice, but higher than Wheat (07). Foxtail (10), Sorghum (09), Barnyard (09) millets as well as Kodo millet (08) secured higher value than Wheat, but lower than rice. Little millet secured the same score value like that of Wheat. So, none of the millets were inferior to wheat, but Little, Kodo, Barnyard millets and Sorghum were inferior to Rice. To conclude, only Finger millet and Pearl millet were superior to both rice and wheat.

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RICE BRAN OIL (RBO) – A VERSATILE EDIBLE OIL

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Introduction

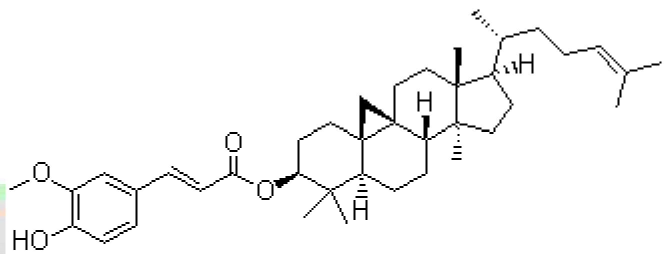
Rice (*Oryza sativa* L.) is the prominent grain consumed by about 3.5 billion people worldwide. The rice bran oil (RBO) derived from the rice bran, which is one of the important byproduct during rice milling process, is one of the versatile and most health-benefiting oils, which can help to remove free radicals in human body and to prevent diseases. The percentage of oil in rice bran is from 18% to 23%. It is an oil rich in essential fatty acids, and it is rich in nutritional components such as dietary fire, vitamin B and E, and minerals such as iron, calcium, potassium, chlorine, magnesium, and manganese The fatty acid profile of RBO reveals about 19% saturated (palmitic acid), 42% monounsaturated (oleic acid), and 39% polyunsaturated (linoleic acid), so rice bran oil is one of the healthiest and most nutritious edible oils. Based on the nutritional point of view, the interest in rice bran oil has been growing, mainly because of its health benefits, which include a reduction in both serum and LDL cholesterols. The healthy vegetable oil of RBO is a suitable source of various antioxidants such as oryzanol, tocopherols, tocotrienols, squalene, and phytosterols.

This healthy vegetable oil also has greater oxidative stability and longer shelf life than other vegetable oils. This healthy oil is also a rich source of monounsaturated fatty acids (n-9

MUFA), n-6 PUFA, and sterols, as well as it has been shown to reduce bad cholesterol. Rice bran oil's other components like tocotrienols and squalene have powerful anti-cancer and anti-ageing properties.

γ-oryzanol and its importance

In rice seeds, γ-oryzanol exists mainly in the outer layer of the bran, such as the outer seed coat, and the nacre layer, and it is reported that 91% of γ-oryzanol is present in the oil body of rice bran. More than 23 steryl ferulates have been found in γ-oryzanol four of them, including cycloartenyl ferulate, 24-methylenecycloartanyl ferulate, campesteryl ferulate, and β-sitosteryl ferulate, dominate in most rice cultivars. Approximately the concentration of γ-oryzanol in brown rice bran is 60–65 mg 100 g^{-1} .



In addition, content and composition of γ-oryzanol vary significantly in different rice products and also the content is differ significantly in rice cultivars with different colors. For example, the average γ-oryzanol content in black-purple, red, green, and brown rice cultivars is 54.2, 47.3, 44.3, and 43.3 mg 100 g^{-1}, respectively (Tsuzuki et al., 2019). γ-oryzanol has been increasingly demonstrated to have cholesterol-lowering and antioxidant effects in animals with significant human health promotion potentials. Despite these above mentioned various proven and expected biological activities, the biosynthetic pathway of γ-oryzanol in plants is still unclear. Considering its molecular structure, the biosynthesis of γ-oryzanol in plants may start with the synthesis of sterols and ferulic acid followed by the esterification of ferulic acid and sterols. However, the enzymatic system involved in the esterification reaction of ferulic acid and sterol is still vague. It is reported that microsomal phytosterol acyltransferase can convert phytosterols into sterol esters while no esterases that esterify ferulic acid and sterols have been identified. Therefore, understanding the esterification of ferulic acid and sterols and its regulation is necessary to elucidate the biosynthesis of γ-oryzanol for the future improvement of rice grain quality.

Smoking point of RBO

Heat stability of the frying oil is mainly governed by two factors: the fatty acid composition and the presence of antioxidants and antioxidant precursors. Frying oil should have a low level of polyunsaturated fatty acids such as linoleic or linolenic acids and high level of oleic acid with moderate amounts of saturated fatty acids. Then only, it can withstand high-temperature cooking methods like deep frying and stir frying. Rice bran oil has about 30% linoleic acid, 44% oleic and about 23% saturated fatty acids. It has been reported that presence of natural substances such as squalene, sterol fraction, quercetin . Oryzanol and ferulic acid enhance the stability of vegetables at a higher temperature. Due to this reason the RBO has a high smoke point of 232 °C (450 °F), which is higher than most other vegetable oils

Non – Nutritional use of RBO

Non-food uses of RBO include feed formulations, soaps, and glycerin. Waxes may be used as a carnauba wax replacement in confectionery, cosmetics, and polishing compound products. The use of RBO as a specialty ingredient in the cosmetic/personal care market, where the demand is for natural, value-added healthy ingredients, is growing. The presence of γ-oryzanol in RBO can function as a protective agent against UV light-induced lipid peroxidation, and as a consequence can be used as a potent sunscreen agent. The ferulic acid and its esters present in γ-oryzanol stimulate hair growth and prevent skin aging. RBO also contains approximately 500 ppm of tocotrienols. When applied to the skin, T3 penetrates and is absorbed rapidly. T3 accumulates in the skin and acts as the first defense layer with antioxidant properties. As a consequence, T3 stabilizes the free radicals generated in the skin when exposed to oxidative rays. T3 will thus protect against skin damage induced by ultraviolet rays.

Health benefits of RBO

- **Skin health**: Due to high antioxidants in RBO , it supports skin health. The anti-inflammatory properties can help to repair skin damaged by UV rays.
- **Brain function**: It may help enhance brain function and balance endocrine hormones.
- **Weight loss**: It may help managing obesity by weight loss.
- **Immune health**: It may improve human immune response.
- **Bad breath**: Oil pulling may reduced bad breath.

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INFOGRAPHICS- AN ALTERNATIVE TO CONVENTIONAL TEXT COMMUNICATION METHOD

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Introduction

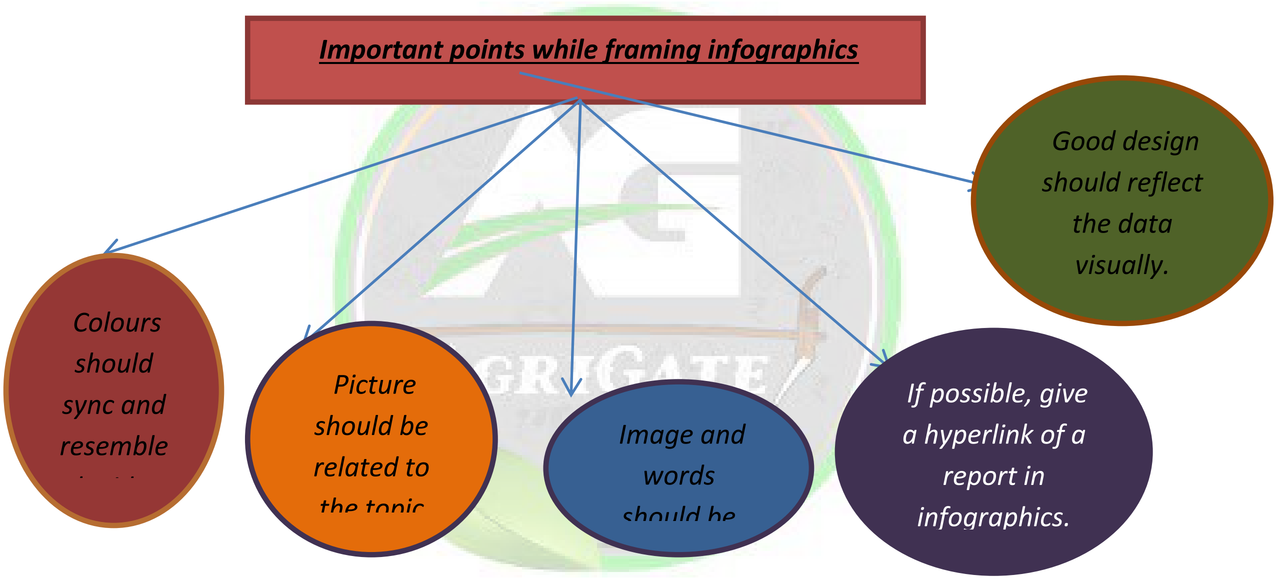
Several reports are annually published by all the national and international institutes to the public so that the information is available to all and can be accessed easily. Some of the reports contain graphs but some of them not. These have explanation in the form of text paragraphs making them very voluminous and takes a lot of time to analyse these reports. Similarly, the students find it difficult to remember all the texts of the books since many books are all black and white and create disinterest among them. Instead of the large paragraphs, visual aids are much effective. According to the Visual Teaching Alliance, the brain can process visuals 60,000 times much faster than the texts helping the brain to easily remember all the information. Thus, the visuals are much efficient in dissemination of information as well as in learning and remembering large voluminous data. Therefore, infographics are better alternative to the conventional text writing and communication. The infographic refers to image representing an integration of design and visually pictured data to help the organizations convey their messages in a concise fashion (Milovanovic and Ivanisevic, 2014). In other words, an infographic consists of graphics/images with little text that conveys the message easily to the target population. Thus, infographics are gaining much popularity these days because of the following reasons:-

- They are easily processed by brain in lesser time compared to the text.
- All the information is available in one place which helps in easy storage of the data and its easy sharing.

- They are more eye catching than written document reports as they contain attractive colours, designs and different shapes.
- They are good tools of communication and learning.
- The message gets easily conveyed through the graphics and images.

Infographics

Although the infographics are much efficient and effective, yet it does not mean that there is complete guarantee that the message which the creator wants to convey is interpreted by the receiver as it was. The infographics can only be effective if they are created carefully keeping in mind the intend of the message. Some of the important points while framing an infographic are as follows:-



Here, is an example of simple infographic prepared by us showing major weeds, disease and insect-pest found in the rice crop. The data of area and production of rice crop in Himachal Pradesh is taken from State Statistical Abstract of Himachal Pradesh, 2021-22. Thus, in a way, infographic can be used for showing annual reports, research work, book material, students' work, study material etc.

Infographics are also beneficial as pictorial images take less time and energy and the attractive shapes, colours and images are eye catching to the readers. It also grasps reader's attention and adds interest in reading. A number of studies are conducted worldwide by different researchers depicting the usefulness of infographics. Romano (2019) in a study related to infographics found that on an average 20% of the words in the pages are read by the reader and the articles without images seemed less interesting which made the readers in not sharing the articles which were not fully read by them.

Conclusion

Thus, it can be concluded that the infographics are much efficient in dissemination of information and are quite helpful in easy remembering, analysing and interpreting the data. Therefore, the infographics can be used by the institutions, universities and authors to create an interest among the readers and to facilitate the communication process.

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DEFENSE RESPONSE OF DIFFERENT CHICKPEA CULTIVAR AGAINST *MACROPHOMINA PHASEOLINA*

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Abstract

In Modern era plant play a crucial role and have received the potential releases of secondary metabolites and defense chemicals have drawn considerable attention. Plants exhibited toxicity towards pathogens but how they combat such stress was a little studied. So, this study was planned to explore the consequences of oxidative stress and secondary metabolite secretion of chickpea cultivars against *Macrophomina*. Toxins of pathogen applied to *Chickpea* plants and their biochemical parameters were studied. *chickpea* seeds were inoculated for germination with different combinations of toxins in Murastige and Skoog medium. Plants exhibited major biochemical alterations as a consequence of oxidative stress and this stress can amend the existing balance between antioxidative defense mechanisms and cell functionality. This study establishes that secondary metabolites production increased significantly in response to pathogen.

Keywords: Chickpea, *Macrophomina phaseolina*, biochemical parameters

Introduction

The intimate interactions between cultivated crops and bacterial, viral and fungal pathogens often results in serious outbreak of disease. 'Plant disease' is defined as "physiological disorder" or structural abnormality that is harmful to the plant or any of its parts or products or that reduces its economic value. Plants are host to thousands of infectious diseases caused by many living or nonliving agencies like viruses, bacteria, fungi, nematodes and stress condition. Relatively small proportions of pathogens successfully invade the plant host and cause diseases (Guiñazú et al, 2012).

Chickpea (*Cicer arietinum*) is the second most important cool season legume crop in the world. Chickpea is a self-pollinated crop. Cross-pollination is rare; only 0-1% is reported (Singh, 1987; Smithson et al, 1985). Supplementation of cereals with high protein legume is potentially one of the best solutions to protein-calorie malnutrition, particularly in the developing countries. Chickpea is legume crop in the developing world and it not only serves as a good source of nutrition to the people but also improves the soil. However, this crop is susceptible to various biotic stresses and hence several strategies have been attempted to produce varieties resistant to these stresses and also to harvest high yield capacity. Fungi are of major significance as mutualistic symbionts and parasites of plants, so their study is an important part of plant sciences and plant pathology (Choudhary et al, 2011).

Macrophomina phaseolina (Tassi) goid a soil inhabiting fungus is an important root pathogen and causes charcoal rot in over 500 plant species including chickpea (Patil, 2011). It remains to be a challenging task in terms of management, since it is soil-borne in nature. It is distributed worldwide and is prevalent in arid, sub-tropical and tropical climate, especially in the areas with low rainfall and high temperature.

The fungus is an important pest of chickpea causing significant loss in its yield. It is an important phytopathogenic fungus infecting a large number of plant species and surviving for up to 15 years in the soil as a saprophyte (Kaur et al, 2012). It causes severe yield losses in epidemic years (Arora et al, 2012). Climate conditions of the desert favor the growth and survival of *Macrophomina phaseolina* that is why this disease is quite prevalent in Rajasthan and leads to heavy losses of this crop.

Phaseolinone appears to be most important phytotoxin of *Macrophomina phaseolina* and induces disease symptoms in plants (Gopalakrishnan et al, 2011). It is a non-specific exotoxin that is highly stable and non-biodegradable even at high temperatures. The direct role of toxins in pathogenesis induced by *Macrophomina phaseolina* has been supported by important role of cell wall dissolving enzyme in disease initiation and progression.

The plant defense response is a multicomponent system and is of broad spectrum. Resistance in plants is manifestated by the inability of pathogen to grow or multiply and spread and often takes the form of hypersensitive reaction, systemic acquired resistance or induced systemic resistance (Delaney et al, 1994; Xu et al, 1994; Wu and Bradford, 2003). Among all induced responses, production of "Pathogenesis Related (PR) proteins" is most important because they can lead to the increased resistance of the whole plant against a pathogenic attack (Adrienne and Barbara, 2006) such as chitinases, which hydrolyze chitin, a linear polymer of β-1,4-linked N- acetyl glucosamine residues and one of the major cell wall components of many pathogenic fungi (Bartnick, 1968; Wessels and Sietsma, 1981). These enzymes inhibit fungal growth *in vitro*, causing lysis of hyphal tips (Mauch et al, 1988). The transfer of chitinase genes to other plants may decrease or delay the disease symptoms (Grover and Gowthaman, 2003).

The study is focused on the effect of fungus *Macrophomina phaseolina* on growth of chickpea plant via monitoring various biochemical parameters which play important role in defense response upon infection with the pathogen.

Review of literature

Chickpea (*Cicer arietinum*) is an important leguminous crop being grown on a large scale in Asia particularly in India which is the largest producer of chickpea in the world contributing 80% of world production. One of the major hurdles in the production of high quality seeds and yield of food crops is the difficulty in control of plant diseases. The control of plant diseases is thus of fundamental importance and is a major objective of plant breeding and pathology programs and agriculture based industries. *Macrophomina phaseolina* a host pathogenic fungus of the family Botryosphaeriaceae has various synonyms *viz. Macrophomina phaseolina* (Tassi) or *M. phaseoli* (Maubl.); *Macrophoma conchoci* (Swada); *Sclerotium bataticola* (Taub.).Von Arx (1981) has also referred it as *T. phaseoli* under the genus *Tiarosporella*. This organism is the coelomycetous synamorph and has as yet no known teleomorph.

Macrophomina phaseolina produces dark sclerotia, pycnidia and conidia in routine cultures. Conidia lack appendages and become brownish-black to bottle green at maturity (Arora et al, 2012). These are cosmopolitan soil saprophytes and well known facultative plant pathogens. It causes charcoal root rot infection in about 500 different plants around the world. It has a wide host range including species of chickpea, soybean, cotton, corn, cluster bean, sorghum and other economically important crop plants. *Macrophomina phaseolina* is an optional saprophyte that survives in the soil because of microsclerotinia formation which is pseudoparenchymal tissue mass resistant to adverse environmental conditions (Shanner et al, 1999). Infection is initiated when the root dripping of susceptible plants comes into contact with microsclerotinias that remain latent in the soil allowing their germination and subsequent penetration in the plant (Smith et al, 1989; Kendig et al, 2000).

After the death of the plant the microsclerotia are incorporated into the soil through the decomposed plant tissue litter where they can be viable for more than three years. Micro-sclerotinias in the soil and plant waste constitute the greatest source of *Macrophomina phaseolina* inoculum to cause new infection (Smith et al, 1989; Kendig et al, 2000; Baird et al, 2003). *Macrophomina phaseolina* grows rapidly in culture over a wide range of temperature, the optimum and maximum values being 24ºC and 35ºC. The thermal death point has been found to be 70ºC. The fungus is capable of growing well over a wide range of pH (4.8 to 8.4), the optimum being 6.6 (Mathur, 1968). Among media, potato dextrose agar and oat meal agar are most suitable for the growth of the fungus. It produces typically dark, generally black sclerotia. In culture *Macrophomina phaseolina* produces colonies of various colors ranging from white to brown to gray. The mycelium becomes darker with age. The fungus may produce abundant aerial mycelium. The sclerotia are black, smooth and varying from spherical to oblong to irregular shaped.

1. Toxins of *Macrophomina phaseolina*

Mathur (1968) first observed that *Macrophomina phaseolina* produces phytotoxic substances in culture that showed disease symptoms similar to that of a pathogen. It produces a number of phytotoxin namely asperlin, isoasperlin, phomalactone, phaseolinic acid, phomenon, phaseolinone (Dhar et al, 1982; Mahato et al, 1987; Bhattacharya et al, 1992). A large number of fungal phytopathogens produce disease related phytotoxins, which interact with the cell machinery.

Chemical structure of phaseolinone

Later one toxin was named as phaseolinone (Dhingra and Sinclair, 1974; Siddiqui et al, 1979) which appears to be the most important toxin that induces disease symptoms in plants. It is a non-specific exotoxin that is highly stable and non-biodegradable even at high temperatures. It affects seed germination, seedling growth and cause necrosis in tissue cultures, during callusing and regeneration. This toxin is responsible for wilting of seedlings and inhibition of seed germination.

The isolation and structure of another toxin, phaseolinic acid was reported from the culture of filtrate of *Macrophomina phaseolina* (Mahato et al, 1987). This toxin had no effect on seed germination or seedling growth but was able to induce non-specific leaf necrosis in several plants.

Plants have developed various mechanisms to defend themselves against these fungi which include the production of low molecular weight secondary metabolites, proteins and peptides having antifungal activity (Leiter et al, 2005). Numerous fungi have been invariably implicated in causing disease in plants with synthesis of compounds like phytoalexin and pathogenesis related proteins (Shoham and Levitz, 2005). Chitinase can be isolated from chickpea (*Cicer arietinum*) which is major component of fungi cell wall (Simmons, 1994; Høj and Fincher, 1995). Cell lysis and cell death occurs as a result of hydrolysis of glucans present in the cell wall of fungi (Vallad and Goodman, 2004).

Chitinase isozymes in plants have been divided into seven classes based on their primary structure (Neuhaus, 1999). Several chitinases of classes I, II, and III inhibit fungal growth *in vitro* (Mauch et al, 1988; Sela Burlage et al, 1993). The transfer of these chitinase genes to other plants may decrease or delay the development of disease symptoms (Grover and Gowthaman, 2003).

Scope of the work

The screening of germplasm to obtain resistant varieties is important because these can be used in plant breeding programme, breeding lines and mapping population for *Macrophomina phaseolina*. The direct role of toxins in pathogenesis induced by *Macrophomina phaseolina* has been supported by important role of cell wall dissolving enzyme in disease initiation and progression. A large number of fungal phytopathogens produce disease related phytotoxins, these toxins interact with the cell machinery. Overall findings may suggest the mechanism of induced resistance in chickpea plants and together with the study of toxins and mechanism of gene regulation will open new ways for the plant genetic engineering technology for crop improvement.

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SHORELINE PROTECTION STRUCTURES AND IT'S IMPACTS

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Abstract

Coastal ecosystem and beaches are one of the pleasant gift of nature. These dynamic areas face a range of erosional processes, prompting the widespread use of coastal armouring, particularly in developed nations. With population growth, beach erosion, and rising sea levels, the prevalence of protective structures like seawalls is expected to rise. However, while seawalls offer strong protection against waves and flooding, they disrupt natural coastal processes and hinder sediment exchange, exacerbating beach erosion and impacting biodiversity. Alternative management methods such as enhancement of existing seawalls through techniques like estuarine vegetation establishment and artificial reef habitat provision aims to mitigate the negative effects of seawall construction on coastal ecosystems, promoting habitat preservation and biodiversity conservation.

Keywords: Coastal ecosystem, Coastal armouring, Estuarine vegetation, Artificial reef

Introduction

With the elevated rate of global population, urbanization as well as development near the coastline countries, there has been an increasing pressure in the coastal ecosystems worldwide

(Clark, 1996). Coast being very dynamic both spatially and temporally are exposed to a wide range of erosional process (Balaji *et al.*, 2017). Coastal armouring has been widespread in developed nations and is expected to excel more in near future concerning over the abrupt increase in population, erosion of the beaches and rise in sea level (Dugan and Habbard, 2010). Coastline or shoreline protection structures are the measures to alter the effects of ocean waves, currents and sand movement. These protective structures are evolved to dissipate the energy of waves either by absorbing the energy on the beach or by dissipating/diverting the same before the waves approach the beach (Kabir *et al*., 2018). To address the issue of managing the erosion of the beaches, three alternative methods are available namely; Hard stabilization, Soft stabilization and relocation or retreat (Pilkey and Wright, 2014).

The term "Hard stabilization" refers to the hard structures that are permanently located and its withdrawal once located is near to impossible. It includes the structures that built perpendicular to the shores such as groins or parallel to the shores like seawall, revetments or bulkheads (Pilkey and Wright, 2014). On the other hand, "Soft stabilization" includes artificial nourishment and dune consolidation. Relocation or retreat refers to the practice of moving structures back apace with the shoreline retreat. Among the hard stabilization structures, seawall is the most common and widespread one (Kabir *et al*., 2018). In this synthesis, we will discuss the types of seawall, its impacts on beaches as well as some alternatives of these structures.

Seawall and its types

A seawall is a shore-parallel structure constructed to prevent landward retreat of the shoreline and inundation or loss of the upland by flooding and wave action (Kraus and McDougal, 1996). It is used to shield areas of human habitations and leisure activities from the negative effect of waves, tides, and tsunamis. Seawalls are usually built on coasts experiencing chronic erosion or in danger of inundation, and where further shoreline recession and flooding must be prevented (Kraus and McDougal, 1996). Since the sea walls are stationary features, they conflict with dynamic coastal nature and hinder any sediment exchange between sea and land. Seawalls can be large or small, high or low, and constructed of a range of materials including wood, plastic, concrete, rock, construction rubble, steel, old cars, aluminium, rubber tires, and sandbags .There are several arrangements for seawall i.e. Curved faced seawall, Stepped face seawall, Rubble mound seawall, Vertical seawall, gravity, Steel sheet pile and Concrete block seawall etc. (Kabir *et al*., 2018). Some of them are discussed below.

Curved face seawall:

This type of seawall is designed to shield high wave action effects and is constructed using sheet pile cut off wall to avoid the foundation material loss by overtopping of water and storm drainage. The toe of the wall is built from large stones.

Stepped face seawall:

This type of seawall is used to resist moderate wave actions. Reinforced concrete sheet piles with tongue- and- groove joints are employed to construct this. Either grouts are filled or geotextile fibre are installed to fill the gaps created between sheet piles to form a sand-tight barrier.

Rubble mound seawall:

This type of seawall can resist strong wave actions and its construction might be cheaper and easier. The main advantage of this type of seawall is the provision for readjustment and settlement without any structural failures. The dimensions of the seawall are determined based on site conditions.

Merits and Demerits of seawall

Merits of seawall:

Seawalls are the strong protection measures that can withstand very high energetic wave actions and they offers protection to the coastal communities as well as aids to the coastal development. Seawall protects the beach from erosional activities and flooding from the waves, providing opportunities for sightseeing and recreation additionally (Kabir *et al*., 2018). Unlike other shoreline protection measures, seawall requires less space as they are constructed vertically.

Demerits of seawall:

Construction of seawall is a costly affair and it requires careful maintenance to prevent shrinkage, de-bonding and fracturing (Kabir *et al*., 2018), besides dissolving the beaches and making them non-functional for beachgoers. It ruins the natural landscape of the sea and can destroy the formation of intertidal beaches as well as the coastal wetlands which are habitat to a huge biodiversity resource. The reflected waves from seawall can significantly sour the beach and hence continues to lower the beach which will reduce the recreational value of the beaches. Additionally, reflected waves after hitting the seawall remains strong which ultimately erodes the seawall.

Impact of seawall

Beaches represent dynamic ecosystems influenced by both watershed processes of hill erosion and oceanic factors such as waves and sea level rise. They serve as a natural shield against storm surges and offer crucial habitats for various species. The construction of seawalls can protect the development temporarily, but it ultimately exacerbate beach erosion process and finally leads to loss of the beach. Hall and Pilkey (1991) pointed out three types of erosion linked with sea walled beaches i.e. Placement loss, Passive erosion, and Active erosion. Placement loss occurs when a shoreline structure is constructed along the shoreline and thus reduces beach width. Passive erosion happens when coastal dunes are replaced by hard stabilization, fixing the landward boundary. Active erosion accelerates due to seawalls, altering sediment supply and shore processes.

The changes in beaches or intertidal zones can impact community diversity, especially affecting upper zones. Narrowing beaches due to armouring disproportionately affect upper zones and reduce prey resources for shorebirds. Mobile invertebrates' distribution and survival may decrease due to tidal migration restrictions by seawalls.

Coastal armouring significantly impact beach width, macroinvertebrates, and shorebirds. Erosion protection structures directly affect macrophytobenthos and zoo benthos, reducing benthic invertebrates due to sediment accumulation and transport. Coastal structures may obstruct nesting sites of sea turtles, leading to abandonment or failure of nest construction and ultimately increasing mortality from inundation or erosion. Seawalls contribute to the loss of tidal flat ecosystems, vital for diverse biota. Salt marsh plants in upper intertidal zones support various birds, while lower zones harbour dense benthic invertebrate populations crucial for seabirds' rest and breeding. Beaches are complex ecosystems vulnerable to human interventions like seawall construction, which disrupts natural processes and threatens biodiversity. The loss of beach habitats and tidal flat ecosystems underscores the need for sustainable coastal management strategies to preserve these invaluable environments.

Techniques to improve existing seawall

Numerous techniques can be employed to improve the environment and habitat values of existing seawall. These techniques can be applied to existing seawall surfaces, as well as to the estuary bed of the coast. While a single technique may have limited effects, combination of two or more techniques can have combined impact (Wiecek, 2009). Some of these techniques are discussed below.

Establishment of estuarine vegetation such as mangroves directly in front of seawalls

Planting of mangrove seedlings in a fringe pattern in front of the seawall can serve as a beneficial strategy in places where a seawall doesn't face deep waters and there's a beach or mud flat during low tide. This not only provides habitat but also encourages the deposition of sediment and protects the base of the seawall. However, this approach might not be suitable if the exposed mud flat is identified as crucial habitat for shorebirds, especially migratory ones. When mangroves are introduced in front of such seawalls, it's advisable to shield the seedlings from waves and debris by constructing temporary fencing to enhance their chances of establishment (Wiecek, 2009).

Providing artificial reef habitat immediately in front of seawalls

Considering the water depth, a range of elements like woody debris to man-made structures such as artificial reefs can be used to create artificial habitat. These elements serve multiple purposes, including offering a solid surface for organisms to attach to, providing shelter and shade for small fish, and also aids in erosion prevention (Wiecek, 2009). However, these measures shouldn’t be implemented if there is existing seagrasses bed in front of the seawall.

Providing variation of texture and form on the seawall surface.

Increasing the roughness and texture of seawalls might be an alternative option for creating and increasing surface conditions more favourable for organism growth and colonization. Various techniques could be employed to augment the roughness of existing seawall surfaces, such as incorporating objects like prefabricated hollow concrete knobs and integrating large woody debris.

Conclusion

Urbanization has altered and continues to alter estuarine foreshores by causing direct habitat loss and fragmentation. Conversely, safeguarding coastal communities and fostering sustainable development are equally crucial. Hence, suitable measures like reduction of the seawall slope to provide a gradient curvature; incorporation of microhabitats such as pools, crevices and boulder; maximising the surface roughness and texture etc. should be implemented while constructing new seawall along with improving the environmental attributes of the existing seawalls.

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INDOOR PLANTS- UTILITY IN LANDSCAPING

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Introduction

The House Plants or Indoor Plants, have become a necessity in the homes of the affluent west, but even in some affluent Indian homes these types of plant are also now finding a prominent place. Interiorscaping or Indoor landscaping is the art and science of selecting, placing and maintaining plants to improve and enhance the appearance of the indoor environment (Kayina *et al*., 2015). Research shows that properly maintained plant-filled rooms contain 50-60% fewer airborne molds and bacteria than rooms without plants. Indoor plants are used to beautify the areas inside the house. It is less costly to decorate the interior of a room with live plants compared to flowers, which are becoming costlier day by day and besides they are to be replaced frequently. On the other hand, with little care, a well-chosen house plant will continue to decorate a room for a period of time. The initial investment may be comparatively high but it proves economical in the long run.

Though the fashion of growing house plants became universally popular during the past three or four decades, definitely it is not a new art. In the ancient civilizations of Egypt, India, and Rome it was not unusual to bring pot-grown or tub-grown plants inside a room for the purpose of decoration. In Europe, particularly in Britain, during the seventeenth, eighteenth, and nineteenth centuries it was a common practice for the well-to-do people to grow exotic house plants for interior decoration.

The indoor plants can be placed in the following areas.

1. Open zone: This is available in roof terraces. This zone is very warm especially during summer in inland plains. Plants like Agave and cacti, which can tolerate reflected heat, can be selected for the above purpose.

2. Shade of a tree in front of a house: Places near the eastern side of the building may be considered for growing certain house plants which can easily come up under shade. Most of the foliage plants like Crotons, Eranthemum, Dracaena, Asparagus are preferred as potted plants in the area.

3. Varandah of a house: This area normally gets only diffused light and the air environment is also good. The plants best suited for growing in verandahs are palms such as Livistonia, *Areca lutescens*, ferns and Begonias etc.

4. Living room, drawing room *etc.:* In these places, we can keep the plants either near the window or away from it. Near a window plants with brighter foliage and occasionally herbaceous flowering plants are preferred, while plants with drooping foliage like Zebrina, Sedum, Mesembranthemum are preferred in the former cases.

Selection of Indoor Plants

The plants which are generally grown in the houses are of two kinds. In the first category includes "the flowering plants" such as African violets, azaleas, geraniums, *etc.*, which are spectacular in appearance by virtue of their colourful flowers. But once the flowering is over, these plants have very little use inside a room and hence their usefulness as house plants is only for a limited period. Then the another category belongs to plants which provide permanent display with their graceful foliage and sometimes with their architectural or unusual form (Khan *et al.*, 2023).

The major capacity of the house plants is to tolerate shade of varying intensity. It should remain evergreen to retain its permanent decorative character, with possible exceptions of *bonsai* which are quite attractive even without foliage because of the attractive outline of the tree. Though green leaves can also be attractive, especially if the shape is unusual or interesting (e.g., *Monstera deliciosa),* leaves with some colour other than green are considered to be more attractive. In some plants the leaves are naturally-coloured as in *Gynura aurantiaca*, *Caladiums* etc., while in others coloured forms of the natural green leaved types are available as in *Peperomia magnoliaefolia variegata, Ficus radicans variegata* and others. Another quality a house plant is expected to have is compactness of its growth habit as space becomes a limiting factor in any house in a congested city.

Now it is possible to describe in a nutshell the qualities expected of an ideal house plant. A house plant should be compact in growth habit, evergreen in nature and should have some amount of shade around its growing environments. In addition, the leaves should be attractive by virtue of their shape or colour. Though the emphasis should be permanence of attraction, handsome flowers produced by house plants should be regarded as a valuable trait. But the combination of good foliage and flowers is unfortunately very rare.

Scindapsus aureus/ Epipremnum aureum

Before procuring a Indoor plant one has to consider many points. The first consideration is that under what condition a plant has to grow, *i.e.*, whether there is sufficient light or the humidity is adequate or the temperature is favourable. Secondly, due thought to be given as for what purpose the plant is needed. For example, if it is for decoration of a small table, the plant should be compact and bushy in nature. Another important point is the experience of the grower in handling a house plants gain, a busy man who cannot spend much time in the care of the plants. A house plant grown in the humid and warm atmosphere of a green house should be hardened off before selling to a customer. It goes without saying that a grower should select a plant with firm and healthy looking foliage and which is also free ill disease and insect pests. Besides the ornamental foliage and flowering plants, cacti and succulents, palms, ferns and some bulbous plants can also be grown inside a house. A miniature Water, *Nymphaea* x *pygmaea helvola* can also be grown indoors in a bowl of at least 30 cm.

Putting the plants in various-shaped plant stands also improves the look of display. Plant stands may be made to accommodate only one plant or it may be branching to hold several pots together. These are generally made of mild steel rods or plates with a heavy base and having a ring to hold the pot. The branching types generally have several protruding hands from the main support at the end of which there wi1l be rings to hold the pots. Plants kept in plant stands should be watered just enough so that there is no drip, or the pots are watered outside and the excess of water is allowed to drain off after which the pots are put back in the stand. Even after these precautions it is most likely that the pots may drip.

There are some other methods of displaying house plants. A live screen can be created in a window by growing light indoor creepers such as different *Hedera helix, Scindapsus aureus,* the "golden pothos" (money plant) and others. The dining space in a drawing or living-room can be separated by growing a screen of creepers in between or placing a vertical garden. Plants grown in bowls or metal hanging baskets can be fixed on the walls by using brackets which will bring a relief to an otherwise empty expanse of a wall. However, one should be cautioned not to overdo the practice of decorating with houseplants.

Other Indoor Plants

For the sake of convenience, the house plants are classified into several groups. The different groups are mentioned below and some important house plants belonging to each group are listed below.

Climbing and Trailing Foliage Plant

The climbing and trailing plants will need support for growing. For light creepers or trailers split-bamboo cane support driven deep into the compost will be enough. The creeper or trailer should be tied to the cane taking care that the knot round the stem is loose enough for the future growth of the plant.

Monstera deliciosa

Philodendron scandens

Hedera helix

A trellis can be made by driving into the soil three or more canes at slightly inclined angle across the centre of the pot. Then crossbars made of split bamboo cane are tied across these canes with thin wires at intervals of 10 cm. For making a screen, thin chicken wire-mesh may be used supported on wooden frame. Moss sticks, also called totem poles, are made by tying sphagnum moss all round and along the wire length of a thick cane and supporting against it generally creepers such as *Monstera deliciosa, Philodendron scandens,* money plant, and also *Hedera helix* having aerial roots

The following are examples of few house plants belonging to this group. **(a) Climber:** *Ficus pumila, Ficus radicans variegata* is a beautiful variegated creeper suitable for hanging baskets. The creamy-white variegation starts from the margins, *Asparagus plumosus, Asparagus sprengeri, Hedera helix, Philodendron elegans, Philodendron laciniatum, Philodendron melanochrysum, Scindapsus aureus* ('Pothos''), *Scindapsus aureus 'Marble Queen'', and Scindapsus aureus ''Tricolour''* and *Syngonium podophyllum*

(b) Trailers: The important plants in this group are: *Chlorophytum comosum variegatum, Fittonia verschaffeltii, Tradescantia jluminensis, Tradescantia jluminensis variegata* and *Zebrina pendula*

Conclusion

It is a known fact that landscaping and interiorscaping adds to the aesthetics of the building and its interiors. Moreover, indoor plants has another advantage of increasing work efficiency and creativity, helping patients recover faster, air purification, noise reduction, energy savings, wayfinding, providing privacy and property security, and increasing the property value.

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HERITAGE PADDY LANDRACE 'KATARNI': A SPECIALTY OF BIHAR

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Introduction

Katarni rice is the most popular and finest quality of scented rice of Bihar and most often used in ceremonial purposes. The word 'Katami' literally means an 'awl with a hook at the end for sewing'. The name Katami has been derived due to the shape of the tip of paddy which is similar to the tip of awl. It is most prevalent in Bhagalpur and adjoining regions of Bihar. It is highly preferred by people for its aromatic flavor, palatability, and beaten rice (chura) making qualities. It contains a good balance or proteins, carbohydrates and fibre, low in calories and fat and ia a good source of some vitamins and minerals

Uniqueness of Katarni paddy landrace towards its journey to GI tag

It is believed that Maharaja Rahmat Ali Khan Bahadur of Kharagpur was the first person who planted Katarni rice in Bhagalpur region of Bihar. Katarni rice is mainly produced in the districts of Munger, Banka and South Bhagalpur region of Bihar. The unique features *i.e.*, aromatic flavor develops only when it is grown in specific geographical area of Bihar with unique soil and climate. The optimum temperature range of 28-30 °C (day) and 18-20˚C (night) along with 10-12 hrs photoperiod is required for flowering in Katarni landrace and grain filling occurs in dim sunshine in 8-10 hrs day period. It flowers between end of October to beginning of November and matures in the month of December. It has a great demand of trading in local market as well as export potential in international market. But the main problem with available Katarni rice is that it is a poor yielder (25-30 t/ha) due to which farmers gradually tending towards non aromatic high yielding rice varieties.

Hence to protect the extinction of this landrace and to promote the interest of Katarni rice growers by providing an exclusive right for growing this finest quality rice and to get a remunerative price through its marketing, an application for getting the geographical indication tag was submitted by the Katarni rice growers' association. Bihar Agricultural University, Sabour served as a technical facilitator for this application, helped to characterize this rice landrace on the basis of morphological, biochemical and genetical traits. Due to these collaborative efforts, the Geographical Indication, GI tag was granted to Katarni rice in 2018 from the office of Intellectual Properties Rights, New Delhi, India (GI no. 553; Certificate number: 312 dated 26-06-2016.

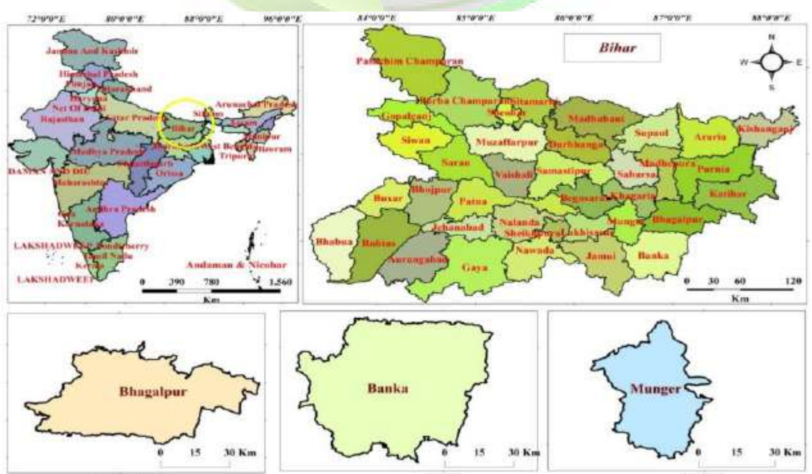

Fig 1: Geographical regions of Bihar (districts of Munger, Banka and Bhagalpur) producing Katarni Rice

Uses of Katarni rice

Katarni rice is most popularly used for performing rituals during Makar Sankranti. It is harvested just before the maturity stage when the spikelets are green, panicles are plucked from the standing plant during the mid-November for making Green Chura or Poha. The final processed product is enriched with strong aroma and consumed with Dahi (curd) during the Makar Sankranti festival in month of January. The small-sized translucent grain of Katarni rice is characterized with strong aroma and after cooking it gains a non-sticky and fluffy texture. It doesn't lose its softness even after 4-5 hrs of cooking. Due to its specific sweet aroma and other properties, it has a great demand potential in both the state as well as country.

Agro-morphological features and its grain characteristics

Katarni variety is relatively tall with 140 to 160 cm plant height, weak strawed, having 125-130 days for flowering and late maturing habit. Other salient features of Katarni rice are: Panicle Length: 22-26 cm; Tillers /Hill: 12-14; Flag Leaf length: 28-30 cm; Flag leaf width: 1-1.25 cm; Panicle /m^2: 300-320. Regarding grain characteristics, it is characterized with 1000 Grain Weight as 12-13 g; L/B Ratio: 2.70-2.80; Amylose%: 21-24; Alkali Spreading Value: 3.8-4.0; Head Rice Recovery: 60-63 (Kumar et al., 2018). Detail Distinctiveness, Uniformity and stability (DUS) characteristics of Katarni paddy variety are given in Table 1.

Table 1: Characteristics of Katarni rice based on DUS traits

DUS traits	Descriptor status
Coleoptile	Colourless
Basal leaf sheath colour	Green
Leaf	Light green
Leaf auricles	Present with no anthocyanin
Leaf collar	Present with no anthocyanin
Leaf ligule	Present, split shape, white colour
Leaf length (cm)	Long (>45cm)
Leaf width (cm)	Narrow (<1cm)
Culm attitude	Erect
Flag leaf attitude	Erect to semi-erect
Lemma (Anthocyanin colouration of keel)	Absent
Stem thickness	Medium thick (0.40-0.55 cm)
Anthocyanin colouration of nodes on stem	Absent
Panicle	Long (26-30 cm), well exerted,
Panicle numbers per plant	Medium (11-20)

Due to its photoperiod sensitivity, flowering is delayed considerably during long-day periods and it suffers from the problem of lodging due to its very tall stature. Hence, there is need to develop dwarf and high yielding and medium maturing Katarni rice. Another problem associated with Katarni rice is its susceptibility to various insect pests and diseases, like stem borer and bacterial blight.

Plant Genome Saviour Community Award for year 2021-22

The Bhagalpuri Katarni Dhan Utpadak Sangh of Bihar have been recognised for Plant Genome Saviour Community Award for year 2021-22. The award was given by Protection of Plant varieties and Farmers Rights, a statutory authority under Ministry of Agriculture & Farmer's Welfare, Government of India for conserving plant agrobiodiversity specifically traditional Katarni landrace with original quality. The award was handed over by honorable president of India, Shrimati Droupadi Murmu during first 'Global Symposium on Farmers' Rights' (GSFR) on 12 September, 2023. The farmers from state selected for the award included Arjun Mandal of Jamui district, Arjun Singh and Dilip Kumar Singh of Rohtas district and Satyadeo Singh of Munger district.

Conclusion

In Global Climate change era, farming sector and specifically agrobiodiversity would be worst affected hence there is an urgent requirement to conserve these unique landraces which have great potential to cope up with adverse climatic extremes and demand among the consumers for its uniqueness. There is an immense scope for reaping the benefits of the new trade opportunities for sustaining the local market and export of Katarni Rice through GI tag of Katarni rice. Further, honouring farmers' community with certainly build a path for promotion of conservation of these landraces by the farmers.

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NANOTECHNOLOGY IN CROP PROTECTION

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Introduction

Nanotechnology is a versatile discipline which embraces information from natural science, chemistry, physics and other fields. Sustainable crop production experiences approximately 20–30% of its total annual loss due to plant infection. Attack by plant pathogens on either cash crops or food crops results in decreased yields, economic loss, and possible crop damage. Controlling the spread of disease appears to be a main task at times. Nanotechnology is described as the operation or assemblies of discrete atoms, molecule, or molecular collections into structures in order to generate novel or extremely diverse assets. The early and efficient pathogen detection is critical for infection resistance and disease management, thus helping to reduce yield damage. The application of nanotechnology in agriculture can modify the agricultural science with advanced apparatuses for quick infection recognition, directed dealing, improved plant nutrient absorption, microbial infection resistance, and ecological stress resistance. Magnetic nanoparticles, quantum dots, and gold nanoparticles are all commonly used nanoparticles for molecular detection. At the preliminary phase, nano-based applications are used for detection, diagnosis, and controlling of plant pathogens due to the application of safeguards for plant harvesting.

Nanotechnology in agriculture

The US Environmental Protection Agency has defined nanotechnology as the science of understanding and control of matter at dimensions of roughly 1–100 nm, where unique physical properties make novel applications possible (http://www.epa.gov/osainter/pdfs/nanotech). The particles referred to in this definition have "particulate between 10 and 1,000 nm in size dimensions that are simultaneously colloidal particulate". Ultimately, When the research into nanotechnology has been completely explored, it can be said to be the science of designing and building machines in which every atom and chemical bond is precisely specified.

Table 1. Types of nanoparticles and their uses in plant pathology.

Type	Definition	Uses
Metalloids, metallic oxides, nonmetals, and their composites	Engineered metals at nanoscale in cubes, spheres, bars, and sheets	Bactericides/Fungicides Nanofertilizers Delivery vehicle for antimicrobials and genetic materials
Carbon nanomaterials	Allotropes of carbon designed at the nanoscale	Multiple uses
Single-walled or multiwalled nanotubes	Graphene sheets rolled into single or multiple tubes	Antimicrobial agents Delivery vehicle for antimicrobials and genetic materials
Fullerenes (bucky balls)	60 carbon atoms in a specific soccer-ball arrangement	Antimicrobial agents Delivery vehicle for antimicrobials and genetic materials
Graphene oxide sheet (reduced or oxide forms)	Graphene oxide sheet	Antimicrobial agents Delivery vehicle for antimicrobials and genetic materials
Liposomes	A lipid enclosing a water core	Delivery vehicle for genetic or antimicrobial products
Dendrimers	Nanomaterial with tree-like appendages that radiate from a central core	Delivery vehicle for genetic or antimicrobial products
Nanobiosensor	A nanoparticle that combines a biological component for detection	Diagnostics, research tool
Nanoshell	Nanoparticles composed of a gold shell surrounding a semiconductor	Diagnostics, research tool
Quantum dots	Inorganic fluorescent, crystalline semiconductor nanoparticles used in biosensors	Diagnostics, research tool

Source : Elmer W and Jason CW (2018)

Nanoparticle for plant fungal disease management

Nanotechnology may play a key role in providing healthier food by promoting precision farming, in particular when facing huge losses due to a wide range of phytopathogens.

Agrochemicals use in farming are reduction due to the increasing popularity of metallic NPs. With the potential to eliminate targeted microbes from plants, soil, and hydroponics, they have outstanding capabilities. Metallic NPs cause hyphal plasmolysis, damaging fungal cell walls, resulting in cell death. As part of a new technology that attempts to synthesize metallic nanoparticles, bio-reduction reactions have been evaluated for bio-reduction of different metals (e.g. iron, silver, zinc, gold, copper). Laboratory and field experiments proved that the metallic NPs have antimicrobial potential.

Nanotechnology based detection of plant diseases

Silver, silica, gold, zinc, and copper are frequently used metallic nanoparticles as antimicrobial agents. Silver nanoparticles were shown to be antimicrobial in both ionic and nano forms, and when tested and studied, the particles were shown to be capable of killing plant pathogens (Sharon *et al*., 2010). Silver has a strong antifungal and antimicrobial mode of action against bacterial and fungal pathogens. Fungicides' hydroxyl radicals-like degradation of fungal and bacterial cell material is achievable with copper NPs. Nano-scale copper particles helped control bacterial blight of rice and mung bean leaf spot disease. Iron NPs come into direct contact with fungal cell membranes and disturb the cell's permeability, reducing the cell's growth and eventually causing death through the development of oxidative stress. Zinc NPs release hydroxyl and superoxide radicals, destroying fungal cell walls, hyphae, and preventing conidiogenesis, leads to cellular death. The gold NPs had greater toxic effects on *Salmonella* than on its macroform. For some plant diseases, nano-silver was found to be highly effective. Nano-sized mesoporous silica particles feature a regular pattern of pores with increased surface area. It's improved delivery, efficiency, and effectiveness for site-specific chemicals.

Nano based agrochemical

Nano-scale materials development has seen considerable progress in the recent years. Nanotechnology promises a bright future while delivering pesticides in a safer manner. Agrochemicals have enhanced solubility when polymeric nano based formulations deliver them at a slow rate, thus increasing their bioavailability

Nano fungicides

Nanofungicide developed which effective in plant protection strategies. Nano emulsions (NEs) with smaller size, lower viscosity, and higher stability required for developing nano fungicides (Bernardes *et al.*, 2014). The active fungicide ingredient is placed within a core surrounded by a membrane in a nanocapsule. Additionally, nanoencapsulation could be utilized in nanopesticide formulations. Polymers and inorganic compounds have been tested for their possible use in nanopesticide formulations for crop protection. For these formulations to be as potent and stable as possible, while still meeting the safety criteria of the systems to the environment and human beings, it is critical that more work be done. Nanotechnology has a large capacity to develop completely new systems and formulations.

Nano-insecticides

Organic solvents are needed to help solubilize insecticides that have low water-solubility, which increases the cost and toxicity. To decrease toxicity, nanoparticles may be used to increase solubility. Another problem is the evaporation or volatilization of the active ingredient. Even though essential oils have a reputation for causing insecticidal effects, the unstable chemical nature of the substances in the presence of air, light, moisture and heat causes to rapidly evaporate. The development of Nano-insecticides is to make the active molecules more stable, which would help ensure that they release at consistent rates over time, resulting in a reduction in insecticide usage and safer for humans and animals. Whereas fipronil, a commercial insecticide, extended the 100 percent mortality window by 3 days, compared to that commercial product, fipronil-loaded with silica extended the 100 per cent mortality window by 3 days, allowing better control of the colony. In groundnut bruchid storage conditions, utilized azadirachtin-loaded zinc oxide or chitosan nanoparticles, the effectiveness over 180 days.

Herbicides

The use of nano sized preparations or nano-materials based herbicide formulations offers unique opportunities for delivering chemical or biological pesticides. Herbicide formulations based on nano materials are effective, solubility and reduce toxicity than conventional herbicides. If early-stage weed control is employed with the use of nanoparticle-based herbicide release systems, the resistance potential will be minimized while the active ingredient's effectiveness will be maintained and prolonged release will be prolonged.

Nanoparticles for plant disease management

Nano-phytopathology

New techniques such as nanotechnology novel and widely used in the treatment of plant infection. Plant pathology is set to offer an exciting future of research with regard to their antibacterial and antifungal properties in the context of nanotechnology. Using nanoparticles to protect the seeds and foliage from pathogens that would otherwise intrude can be the most effective method. Nanoparticles can be successfully applied to disease affected plants with enhanced and effective results due to their extremely reactivity/affectability. Nanoparticles can play their role in plant disease management in following ways-.

- Nanoparticles being used as pesticides and applied to plants directly for the control of disease.
- Nanoparticles as carriers of pesticides
- Nanodevices to detect diseases at early stages.

Effect of nanoparticles on the pathogens/microorganisms, Bacteria and plant viruses

The chemical and physical properties of nanoforms of materials actually shift between their macroform and nanoform. All of these properties transformations ultimately end up with useful real-world applications in plant defense and plant protection. Since nanoparticles have the advantages of both small size and surface area, they influence plant pathogens in a more precise way. The nanoparticles have antibacterial properties, which is most likely the result of the cell wall of the bacteria being broken or of high levels of reactive oxygen species (ROS) being produced. Due to low cost and positive results, antibiotics have been selected for the treatment of bacterial contamination. Although multiple studies have demonstrated that overuse of antibiotics leads to multidrug-resistant bacteria strains. A very powerful strain of antibiotic-resistant bacteria has emerged. The mode of action of nanoparticles is directly linked with the bacterial cell wall, which enables the nanoparticles to control super-resistant bacteria. The various types of nanoparticles were investigated and used to control *Sitophilus oryzae* and baculovirus BmNPV (*Bombyx mori* nuclear polyhedrosis virus) in silkworm (*B. mori*) disease caused by *S. oryzae* and BmNPV (Goswami *et al.*, 2010). To complete their investigation, the researchers performed bioassay, which involved preparing the nanoparticles' solid and liquid formulations; after which, they applied these formulations to rice and stored it in a plastic box with 20 adult *S. oryzae* for seven days. On the first day, the researchers reported that hydrophilic silver nanoparticles were most effective. More than 90% of mortality was gained on day 2, and silver and aluminum nanoparticles were the primary source. Seventy-three percent of the insects died after seven days of exposure to lipophilic silver nanoparticles. But with respect to nanoparticles of aluminum, 100% mortality was observed. Thus, a significant decrease in viral load was found in a hydrophobic aluminosilicate nanoparticle suspension when *B. mori* leaves were used in an ethanolic treatment of grasserie disease.

Metallic nano-particles: effective tool for plant disease management

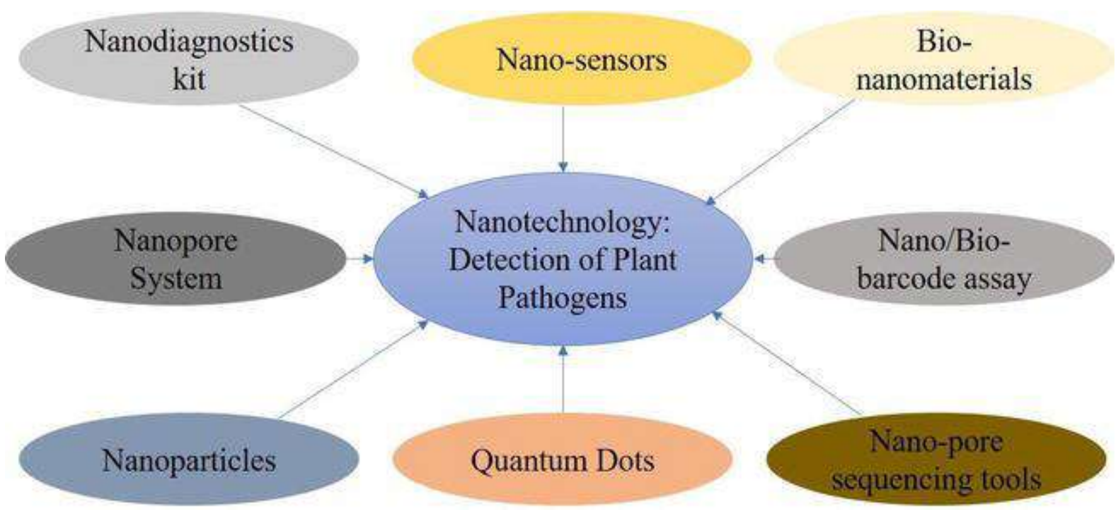

Figure 1. Different nanotechnology approaches for the detection of plant diseases.

Bio-nano materials

There are some bio-nano materials which are categorized through X-ray diffraction (XRD) technique, X-ray photoelectron spectroscopy (XPS), Energy-dispersive X-ray spectroscopy (EDS), UV visible spectroscopy, scanning electron microscopy (SEM), Fourier transforms infrared spectroscopy (FTIR), Coupled plasma spectrometry (ICP), Transmissions electron microscope (TEM) and Atomic force microscopy (AFM) techniques. These bio-nano materials played noteworthy role in field of agriculture, medicine and biology. The increasing usage of bio- nano materials in many areas will enhance their productivity in the atmosphere by developing more analytical tools in nanotechnology for controlled environmental risk management.

Nano bio-barcode assay

The technology of biological barcodes is improving in nanotechnology and incorporating new advancements in nanotechnology to aid in the identification of nonenzyme-containing ultra-sensitive proteins and DNAs. Instead of using an orthodox ELISA, a protein barcode assay could be employed, which is both more complicated and far more sensitive and profound. Because of its dependence on nanoparticles, the nanoparticle-based biobarcode assay is more sensitive to finding pathogens than traditional techniques like ELISA, Real-time PCR, etc. It can also help in early detection of plant diseases. The biobarcode technique consists of two probes.

- **Magnetic micro beads (MMB):** Target recognition and carry an antibody or DNA as a biological probe.
- **Gold nanoparticles (Au-NP):** It has a polyclonal antibody or an oligonucleotide (Bio-barcode) Bio-barcode is a developing technique with the help of advancements in nanotechnology. It is an enzyme free, PCR free technique and highly sensitive for protein and DNA detection.

Nanopore system

Nano pore used in nano-pore systems can be used to examine genetic information at a low cost, have low sample preparation requirements, and operate quickly. In fact, nanopore is a nano-sized pore through which a flow of nanoparticle ions is flowing. Nanopore-based systems determine nucleotides through conductivity changes, which enables them to identify nucleotides because of their lipid membrane. A protein nanopore is injected into a polymer bilayer membrane, which contains a sensory chip to measure current that is associated with the identity of the molecule. Newly, nanopore based sequencing (Nano-SBS) distinguished four DNA bases through discovering four different sized tags released from 5′-phosphate-modified nucleotides at the particular molecule level for sequence determination. UK-based nanopore technology, a portable DNA sequencing machine (MinION) has been enables to sequence a 10 kb sample of single-stranded DNA as well as double-stranded DNA, making next-generation sequencing easily approachable.

Nanodiagnostic kit

Nanodiagnostic kit also called “lab in a box” is used as a small box for measuring important tasks in plants which can be done in small space. A smart kit helps to detect the plant pathogens and can help the farmers in prevention of wide spread diseases. Nanodiagnostic kit contained four myco-sensors which can detect the of ZEA, T-2/HT-2, DON and FB1/FB2 myco-toxins on only one strip used for cash crops like wheat, barley and corn. This method is fast, convenient, and less expensive for finding out if crops have a fungal infection. Antigen and antibodies, the nucleotide sequence in which nano kit can be used, all have multiple additional purposes. Moreover, it can also detect particular gene target, isolation and purification of specific genes.

Quantum dot (QDs)

QDs is another level of nanocrystals that release specific wavelengths of light: Quantum Dots (QDs). There are three-dimensional nanoparticles that have a broad excitation spectrum. Narrow-tunable emission peak, extensive fluorescence lifetime, resistance to photo bleaching, and molar extinction coefficient ten to one hundred times higher than for most QDs. However, one of the findings revealed multiple enzymatic properties of QD-based nanosensors and stated CdTe quantum dots usage as biosensors with specific antibiotic coatings against *Polymyxa betae* specific glutathione-S-transferase (GST) protein. For more efficient results, this device can be used to test plants in under 30 minutes. Although it was concluded that there was a highly sensitive detection of diseased lime trees by showing 100% specificity with a sensitive detection limit for *P. aurantifolia*.

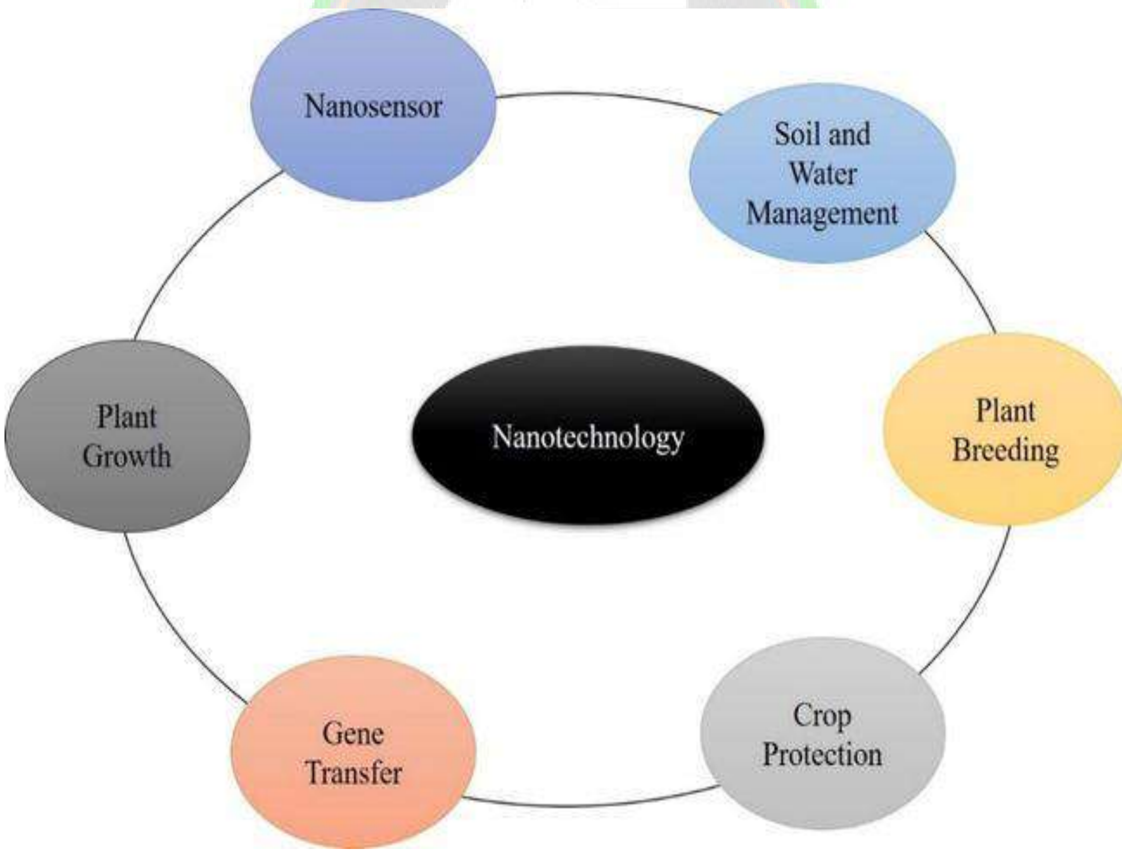

Figure 2. Applications of nanotechnology in plant disease management and crop improvement.

Table 2. Some examples of nanotechnology in agriculture.

Product	Application	Institution
Nanocides	Pesticides encapsulated in nanoparticles for controlled release Nanoemulsions for greater efficiency	BASF, Ludwigshafen, Germany Syngenta, Greensboro, NC, USA
Buckyball fertilizer	Ammonia from buckyballs	Kyoto University, Kyoto, Japan
Nanoparticles	Adhesion-specific nanoparticles for removal of Campylobacter jejuni from poultry	Clemson University, Clemson, SC, USA
Food packaging	Airtight plastic packaging with silicate nanoparticles	Bayer AG, Leverkusen, Germany
Use of agricultural waste	Nanofibers from cotton waste for improved strength of clothing	Cornell University, Ithaca, NY, USA
Nanosensors	Contamination of packaged food Pathogen detection	Nestle, Kraft, Chicago, USA Cornell University, Vevey, Switzerland
Precision farming	Nanosensors linked to a global positioning system tracking unit for real-time monitoring of soil conditions and crop growth	US Department of Agriculture, Washington, DC, USA
Livestock and fisheries	Nanoveterinary medicine (nanoparticles, buckyballs, dendrimers, nanocapsules for drug delivery, nanovaccines; smart herds, cleaning fish ponds (Nanocheck [Nano-Ditech Corp., Cranbury, NJ, USA]), and feed (iron nanoparticles)).	Cornell University NanoVic, Dingley, Australia

Source: (Kalpana *et al.*, 2009)

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IMPORTANCE OF RED RICE FOR NUTRITION AND NOURISHMENT

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Introduction

Generally, consumers prefer white rice over red rice due to its polished surface having appealing aroma, color, taste, and smooth texture. However, now a days health-conscious consumers of our country are willing to substitute white rice with red rice after knowing the health benefits and nutritious quality of red rice. Red, purple, black, brown, yellow, and green rice types have all been grown and consumed throughout Asia's traditional rice-growing regions. Prior to the commercialization of agriculture, this colored rice was favored for its flavor and therapeutic properties, but it is currently going unrecognized. One of the main victims of this bias is red rice. Hence to grow awareness about the red rice importance among the common people, we have highlighted different varieties, various uses including medicinal values and importance of red rice in this article.

About Red rice

Rice with light to dark red colored bran layer is called red rice. Red rice contains polyphenols, anthocyanin and possess antioxidant properties that reduce free radicals in the organism. The red rice varieties with appealing red color contains more nutrition and fiber filled bran. It has 2-3 times higher content of important micronutrients like Fe and Zn than white rice. Some red rice has a low glycemic index. which cause a slower increase in blood sugar levels. Traditional red rice varieties are rich in nutritional values, cultural values, religious values, and have fine aroma and medicinal properties. In the past, many traditional red rice varieties were grown as food and were used in medications. Apart from this, they were also grown for their hardiness to extreme environmental conditions such as drought, flood, pests, diseases, salinity, alkalinity, and the potential to yield well even under minimum management practices.

History of Red rice in India

Before the advent of high yielding varieties of rice, mostly white and red rice formed an important group in almost all rice growing Asian countries such as Sri Lanka, Philippines, Korea, China, Japan and India. In India red rice have occupied a special position since time immemorial. In their respective treatise, the founding fathers of ancient Ayurveda – Sushrutha (400 BC), Charaka (700 BC) and Vagbhata (700 AD) referred to the medicinal value of Shali, Vrihi and Shastika rice. Charaka and other later authors classified the Rakthashali or Lohitshali rice (with red husk and grain) as the best; this variety is considered the most efficacious and it subdues the three deranged doshas- the vata, the pitta and the kapha. Cultivation of red rice were prevalent in the South, East and the hilly tracts of the Northeast and West. A few red grained varieties were cultivated in Kerala, Tamil Nadu, Karnataka, Bihar, Orissa, Bengal, Madhya

Pradesh, and the Northeastern states with areas having unfavorable conditions such as deep water, drought, sandy soils, salinity and cold conditions. Few red varieties were reported from the plains of Haryana, Punjab and Gujarat. Some of the famous red varieties include Matta of Kerala, Patni of Maharashtra and Jatu and Matali of the Kulu valley in Himachal Pradesh. Kunju red rice variety of Kerala is a very popular parboiled small grained, lodging resistant, wind and heavy rain tolerant variety.

While working with thirty-five red rice germplasm lines collected across Himachal Pradesh, it was found that genotypes IC-12180, HPR-2800, HPR-2795, HPR-2913 and HPR-2914 were resistance to leaf and neck blast disease (Praveenkumar and Neelam, 2022). Diverse germplasm and polymorphic trait linked SSR markers of red rice are usually suitable for the detection of economically desirable trait loci/genes for future molecular breeding programs (Islam *et al*., 2018). The red kernelled deep water rice germplasm, Arg Bao, Basudev Bao, Dal Bao, Rayada B8, and Sarmora Bao from Assam showed MR reaction to sheath blight, sheath rot and stem borer infestation (Gogoi *et al*., 2020). In resistance breeding programs around the world, red landraces like Ptb 18, Ptb 19, Ptb 21, and Ptb 33 with broad-spectrum resistance to Brown Plant Hopper have been exploited; Nivara rice has been utilized as a source of viral disease and insect pest resistance; Ptb 10 has been employed for photosynthetic activity, and Lalnakanda has been used as a donor for drought tolerance. (Saxena, 2014).

Red rice cultivation

Red rice is grown in flooded area just like traditional rice, but requires specific water management techniques. They normally need lots of sunlight and are planted in well-drained soil. These seeds have a relatively long growing season, usually around 100 to 120 days. They are known for their resilience and can tolerate different soil conditions, although they prefer fertile soils with a pH level between 6 and 7. The cultivation process involves preparing the field, sowing the seeds, and providing appropriate water levels throughout the growth cycle. Red rice cultivation encourages sustainable agriculture because it uses fewer chemical inputs and is frequently farmed organically. It provides customers with a wholesome and aesthetically pleasing rice substitute for regular rice. Red rice farming techniques encompass a range of scientifically backed practices that optimize the cultivation of red rice varieties. These techniques involve pre and post planting approaches to, maximize yield and minimize potential issues. Before planting farmers often prepare the soil by ensuring it is well drained and rich in organic matter. Farming practices include seed selection (choose high quality and disease resistant seeds), land preparation, sowing (recommended spacing is 20-25cm between rows and 10-15cm between plants), irrigation, weed control, fertilization, pest and disease management and harvesting.

Traditional Red Rice Food Items and Its Importance

Red rice has been used as food in region specific diverse dishes and preparations since ancient times. The prime use of red rice was as a staple food. It is traditionally used to make a variety of dishes, including pongal, puttu, adai, appam, dosai, idiyappam, adirasam, kozhukattai, modakam, payasam, semiya, uppuma, flaked rice, and puffed rice. Several red coloured rice varieties are also used to make biscuits and murukku (a sort of South Indian food). Red Gunja is used to make flat bread and Chapati, while sticky rice is used to prepare the south Indian dish puttu. It is also served to females who reach puberty as a healing dish.

Parboiled rice, including Thondi, Matta, Kunju kunju, Paal Thondi, Kuruva, Chettiny, and Chettadi, is frequently consumed in Tamil Nadu and Kerala. Sarkarai pongal is a dish from Tamilnadu that is cooked with raw red rice, green gramme, milk, and jaagery. Red rice of the Karikagga and Atikaya kinds is used in Karnataka as a tonic and for cooling, while Neelam samba is used in Tamilnadu for breastfeeding women. Red rice from Jharkhand and Chhattisgarh states like Bhama, Dhanigora, Karhani, Kalmdani, Ramdi, Muru, Hindmauri, and Punaigora is full of nutrients and keeps full and satisfied all day. Fried rice balls known as ghila pithas are made and eaten in Assam; traditional sweet rice pithas, karpursal, and Bengali paish are made in West Bengal; and in Himachal Pradesh Jatu red rice is prized for its aroma and taste.

Red rice has been used to make dishes such as Bhaat, Kheer, Meetha bhat, and Chilrhu or Lushke (a preparation similar to a dosa, served with jaggery and ghee). Red rice of the Moorhi kind, which is given as a gift to sisters and married daughters on certain occasions, has great significance in hill people. The key uses also includes Phooli Moorhi (a traditional snacks made by boiling of husked red rice followed by dehusking and then roasted it in sand or oil), Sookhi Moorhi (roasted dehusked red rice mixed with Marijuana seeds), Chewrhi or Hari Moorhi (roasting of green filled panicles), Shakli or Sanse (by making as a batter) and the flour of red rice is also used to make Sidhku (steam cooked balls of red rice flour stuffed with pulse flour and spices). In Japan, coloured cakes and noodles are made with red rice for ceremonial events. Cakes, cookies, gluten-free bread, mixes for peel powder, and yoghurt that has been enhanced with GABA are examples of value-added products made from red rice. For important events like upanayana (the thread ceremony), parched red rice (pori) coupled with jaggery syrup is formed into laddus. It is also used in hawan samagri and as tilak in religious ceremonies.

Medicinal uses

Red rice is considered as highly nutritive with medicinal properties as it possesses antioxidant properties and has a higher content of important micronutrients like Fe and Zn. It has been used widely for its nutraceutical values rather than as food. In Ayurveda, it is written that red rice is the best for health, skin, eyesight, diuretic, improves voice, fertility and it is considered as the best among the Shali varieties of rice. Red rices were highly valued as they had the power to redress the imbalance in the tridosha- the vatha, the pitta and the kapha. Partially boiled red raw rice (Yedurubelthige) was specially used during lactation.

Red parboiled ganjee is recommended in all ailments as it is nourishing, easily digested and assimilated in the body. The rice gruel is an energizing drink and is a good diuretic. The raw red (Manni) is used for promoting lactation and the water left after the washing of rice (Akkacchu) is used as a base in mixing of all the medicinal ingredients in medications. The paste of red rice is used for external applications (lepa) as in skin allergies and for detoxification of the body. Red rice landraces such as Atikaraya and Kari bhatta are used as tonics for milking animals and for curing Jaradi Hunnu or Arasu Hunnu (skin infection). Athikarya variety of red rice is also used to cure diarrhea and paste of red flaked rice can be applied to cracked sole as it relieves the pain.

For Asthma patients, one spoon of latex of *Calotropis* is added to 200 gm of red raw rice-soaked water, it is ground to paste and made into roti by adding sesame oil. One roti for 3 days is recommended. Kalama variety of red rice is used in curing piles or hemorrhoids. Athikaraya and Kayame varieties is specially used in lactation and other medications for pregnant mothers. This stabilizes the foetus and reduces the pain. Karijaddu is used to cure Herpes (sarpa suttu) and skin diseases. This rice is also pound and mixed with jiggery and consumed as tonic to keep the body cool. People with diarrhoea are given kajji made from the rice varietals Kari kagga and Bili kagga.

Proanthocyanidins, which are found in red rice, operate as excellent antioxidants and help to lower the production of atherosclerotic plaque, a risk factor for cardiovascular disease. The nervous system is calmed and relaxed by the calcium in red rice, which also helps to lessen the signs of high blood pressure. The B- complex vitamins offered by natural red rice promotes youthful energy and nourishment to skin and blood vessels. An abundance of minerals in natural red rice helps to nourish the hormonal system, heal wounds, and regulate blood pressure. Chinese use red rice for preparing vinegar, tart, cosmetics, red kojic and red rice yeast which is used for medicinal purposes.

Conclusion

Although India is home to traditional red rice varieties, their consumption and use has been common only among the practitioners of traditional medicine and communities as a part of their cultural heritage. The functional effects and health benefits of these varieties remain unknown to majority of the population due to the insufficient data. But right now, as people became more conscious about nutrition and health, demand for nutritious foods are rising. So, it is necessary to know about the beneficial properties of red rice varieties to leverage their health benefits for natural nourishment of our body by including them in our daily diet or as a special functional food.

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MICROBIAL 3D PRINTING IN AGRICULTURE AND FOOD INDUSTRY

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Abstract

The process of generating three-dimensional items from a computer model by adding successive layers of material is called additive manufacturing, or 3D printing. The fascinating topic of "microbial 3D printing" combines the capabilities of 3D printing with the distinctive characteristics of microorganisms. This novel method called microbial 3D printing has the potential to boost productivity and sustainability in the food and agriculture sectors. This method, which makes use of additive manufacturing microorganisms, has the potential to revolutionize soil health management, food processing, and crop protection. This article gives a quick summary of how this technology is being used in agriculture and to investigate the possibility of employing microbial bioprinting to create sustainable and biodegradable products. By addressing the challenges of scalability, affordability, and regulatory compliance, this technology has the potential to revolutionize agriculture.

Introduction

With accuracy and customization, 3D printing creates objects from computer blueprints. Microorganisms such as fungi and bacteria are used in microbial 3D printing to develop new biological materials or modify ones that already exist. This process makes it possible to manage shape and size in a flexible way, giving items additional features. Utilizing microbe culture, 3D bioprinting has also been applied to the creation of functional materials. A new class of biologically produced functional materials is introduced by the incorporation of bioprinting techniques for printing microorganisms. This method provides biodegradable and sustainable substitutes for conventional industrial processes, especially in the food and agriculture industries.

Microbial 3D Printing

In the multidisciplinary field of "microbial 3D printing," additive manufacturing and biotechnology are combined with the use of microbes to produce materials and structures that are biohybrid and functional. A three-dimensional structure is created by layer-by-layer printing with a substance known as "bio ink," which contains live cells and produces particular biomaterials like biofilms or extracellular matrices (Wan Jusoh et al., 2022). By modifying size, spatial arrangement, and structural morphology, 3D-printed materials provide a dependable and accurate alternative for specialty materials or cell architectures.

3D Bioprinting

It is crucial to remember that various printing techniques affect microorganisms in different ways, therefore it is still necessary to weigh particular benefits and drawbacks when choosing a printing technique. As a result, the most significant printing methods are discussed in-depth in the sections that follow. The printing technologies utilized in 3D bioprinting can be divided into four groups according to the fundamental principles of each technology: Inkjet bioprinting, Laser-assisted bioprinting, Stereolithographic bioprinting, and Extrusion bioprinting (pneumatic, piston, and screw driven). Comparison of the different bioprinting principles is shown in (Table 1).

Extrusion Bioprinting

Micro-extrusion is a fundamental technique in non-biological 3D printing, but it also forms the basis of the extrusion-based method employed in bioprinting. To accurately put bioink, the concepts of controlled deposition and layer-by-layer manufacturing in micro-extrusion can be modified to meet the demands of bioprinting. The bioink is extruded onto a plate by mechanical or pneumatic pressure using a nozzle; the plate can be manipulated in the x, y, and z directions (Assad et al., 2023).

Inkjet Bioprinting

Bioprinting with inkjet technology functions similarly to a standard office inkjet printer. Using an inkjet printer, a design is produced on paper by firing ink through several small nozzles. As a result, an image made up of several droplets that are too small to see with the human eye is produced. For bioprinting, researchers have modified inkjet printing techniques.

These include using vibration or heat to force ink through the nozzles. Although these bioprinters are less expensive than alternative methods, they can only print with low-viscosity bioinks, which may limit the kinds of materials that can be used (Li et al.,2020).

VAT Photopolymerization Bioprinting

UV or visible light is used in stereolithography (SLA), an additive manufacturing process that employs VAT Photopolymerization, to solidify photosensitive polymers. Using photosensitive bioinks, this method can be applied to bioprinting. A tiny quantity of bioink is selectively hardened using a laser. After being moved away from the laser, the scaffold forms on a platform that lets new bioink flow and coat the structure. Until a solid 3D structure is built and any liquid bioink is no longer present, this process is repeated. By applying high pressure, this method resolves the problems brought on by shear stress in nozzle-based processes like extrusion and inkjet bioprinting. The fabrication process is made quick and accurate with stereolithographic bioprinting (Dubbin et al.,2021).

Laser-Assisted bioprinting

One approach that shows promise for tackling problems in microbiology and biotechnology is laser-assisted bioprinting (LAB). It works by first depositing a layer of cells, coating a glass plate with metal or oxide, and then activating a laser. A pressured vapor bubble created by this heat transfers the droplet bioink to an acceptor surface

Table 1 Comparison of the different bioprinting principles (Herzog et al., 2024

Types of bioprinting	**Extrusion bioprinting**	**Inkjet bioprinting**	**VAT photopolymerization bioprinting**	**Laser-assisted bioprinting**
Advantages	Flexibility	Inexpensive	Free of nozzles and high resolution	Free of nozzles and high resolution
Disadvantages	limited resolution, mechanical damage near the nozzle	Mechanical damage at the nozzle	Not versatile	metallic remnants from the layer that absorbs energy
Resolution, µm	>100	50	5	1-10
Speed	Slow	Fast	Fast	Medium
Cell viability	40-80	.85	85	>90

The utilization of LIFT-based techniques facilitates the accurate and highly viable implantation of mammalian cells, particularly human cells, hence enabling the development of artificial organs and complex tissues. Additionally, it presents opportunities for the isolation of new species of microorganisms and the investigation of the interactions between various microorganisms and their metabolism at the level of individual cells (Cheptsov et al., 2023).

Bioink

Researchers have looked exploring for the uses of biological materials in 3D printing techniques, bio-inks that include living cells. Generally speaking, these projects are categorized as "bioprinting" or "biofabrication." To construct three-dimensional structures, bioprinting usually entails the exact layer-by-layer deposition of biological components, such as cells, proteins, or other biomolecules.

An essential element of 3D bioprinting is bioink, which offers a favorable extracellular matrix environment for microbial growth and survival. It guarantees the provision of necessary nutrients, encourages aerobic metabolism, and gets rid of metabolic waste. Because hydrogels are biocompatible and can replicate the extracellular matrix seen in living cells, they are frequently utilized in bioink formulations. In 3D bioprinting, they achieve great biocompatibility, mimic the natural tissue microenvironment, and incorporate nutrition and growth stimuli. Hydrogels can be made in several forms, sizes, or shapes. The bioink utilized in the 3D bioprinting of microorganisms aims to discover a crosslinking technique that facilitates rapid hydrogel gelation and stability, while simultaneously offering physiological conditions and a non-toxic environment for cell encapsulation.

Application of Microbial 3D Printing

Using living organisms as building blocks, microbial 3D printing, integrates the principles of microbiology, biotechnology, and engineering to generate useful structures and materials. This innovative method has enormous potential in a number of agricultural fields, including crop protection and soil fertility control. We explore the idea of microbial 3D printing in agriculture and food industry, understanding how additive manufacturing and microbial biology work together can help us find creative ways to solve urgent agricultural and food industry related issues while reducing their negative effects on the environment. A simple illustration is shown in (fig. 1)

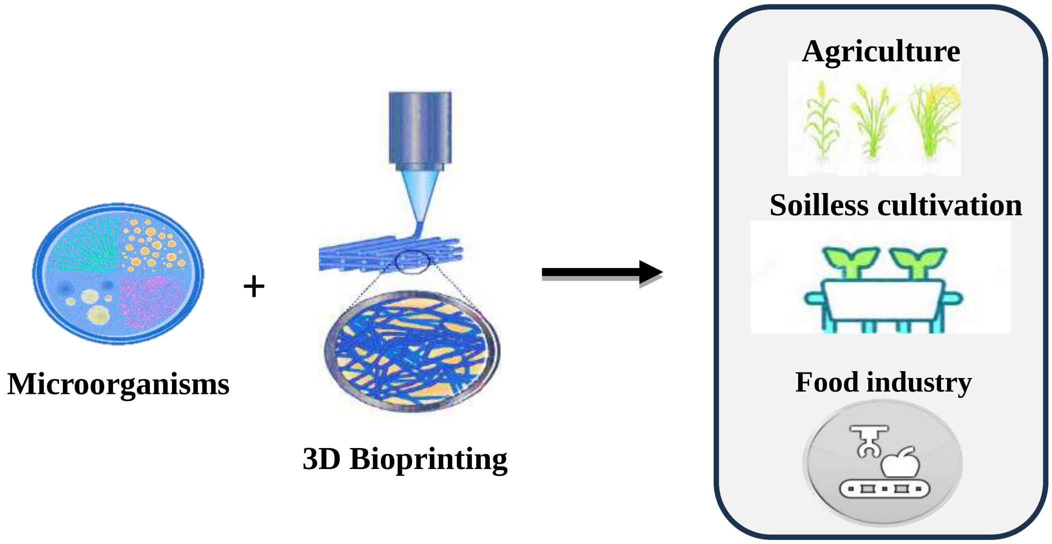

Fig 1. Illustration of microbial 3D printing with applications

1. Agriculture

Laurenson et al., 2022 uses 3D printing and resin to create artificial microbial refugia, or *Rhiome*. A potentially useful technique for restoring soil ecology is the *Rhiome*, which promotes improved microbial development in damaged soils. One type of soil deterioration used in the study is soil compaction, and the use case application is *Rhizobium*, a bacterium crucial to world agriculture. Rhizobial growth support and the suitability of several materials, including resin, for 3D printing were evaluated. Materials made of polylactic acid resin, yeast extract, and mannitol yielded the best results. Rhizobial loading in non-compacted soils was not surpassed by the addition of *Rhiome*, which enhanced bacterial survival in compacted soil to a significant degree. Furthermore, compared to the *Rhiome* made solely of resin, the addition of yeast extract and mannitol to the resin greatly enhanced *Rhizobium* development. It is suggested that the *Rhiome* idea could be a useful tool for restoring the ecological health of soil and enhancing its resilience. In order to evaluate *Rhiome* performance in diverse applications and improve material properties in relation to context-specific performance indicators, more study is needed.

Idbella et al., 2023 investigated the potential uses of ink-jet technology in agriculture. The scientists assessed the ink-jet technology's suitability for use with different insecticides, fungicides, herbicides, and beneficial bacteria because it depends on high temperatures that may change the agrochemicals' biological activity. Through the optimization of droplet size for commercially significant crop protection agents like pesticides and herbicides, they also investigated the potential of ink-jet technology for agrochemical reduction. Because microgreens are small and may be cultivated in highly automated systems, the study concentrated on microgreens production systems. To integrate ink-jet technology with an automated product application system, a specialized system called DEMO was created. The purpose of the study was to determine whether the new method might reduce chemical use by optimizing droplet size, evaluate its compatibility with herbicides, fungicides, insecticides, and beneficial bacteria, and give a test for its use in the production of microgreens.

2. Soilless cultivation

Hydrogels are a class of polymers that naturally expand when submerged in water to form three-dimensional networks. These investigations include improved cell proliferation, vascularization, and customized chemical release, imply that hydrogels may hold the key to develop into viable substitutes for the substrates already employed in soilless cultivation. In order to successfully employ hydrogels in soilless cultivation systems, the material must be phyto-compatible and bio-receptive in order to provide the plants with an environment similar to soil. Using hydrogels in conjunction with AM techniques may lead to the development of substitute soilless cultivation substrates (Kalossaka et al., 2021).

3. Food industry

Zhang et al., 2018 investigates the creation of probiotic-containing cereal-based food structures through 3D printing. Fused deposition modelling was utilized to assess the printability of various dough recipes. The rheological characteristics and microstructure of the dough were impacted by its composition, and these factors were linked to its printability. The "honeycomb" and "concentric" designs are two structures with different surface-to-volume ratios that were printed using two different probiotic-containing dough types. After baking, there was no discernible difference in the probiotic survival between the two structures. Nevertheless, baking time was sped up by raising the structure's surface-to-volume ratio. Probiotic viable counts in the "honeycomb" structure exceeded 106 CFU/g, two logs greater than in the "concentric" structure. The results may be useful in creating novel food products with useful ingredients.

The growing use of 3D printing in daily life and, in particular, in the food industry (kitchen tools and food contact containers) is linked to possible health risks when the printed items are created by specialized facilities and intended for patients with disabilities who are unable to reprint them on a regular basis. The distinctive 3D printing pattern encourages the production of biofilms and bacterial adhesion. In this work, coatings of tetraethyl orthosilicate

(TEOS) and acrylic acid (AcAc) applied by plasma-polymerization have been created to prevent the formation of biofilms on 3D printed PLA materials by *Pseudomonas aeruginosa*, *Escherichia coli*, and *Listeria monocytogenes*. The decrease in bacterial adhesion and biofilm formation may be explained by morphological (a decrease in the distance between peaks) and chemical (the creation of a hydration layer) changes brought on by plasma-polymerized treatments. Comparing AcAc coatings with untreated samples, they demonstrated relative biofilm development of up to 47.7% for *L. monocytogenes*, 50.4% for *P. aeruginosa*, and 64.1% for *E. coli*. These results were higher than those of TEOS coatings (Muro-Fraguas et al.,2020).

Conclusion

In conclusion, A promising new avenue for enhancing food and agricultural productivity as well as sustainability is microbial 3D printing. Using additive manufacturing and microorganisms, it can revolutionize soil health management, food processing, and crop protection. As research in microbial bio manufacturing proceeds, substantial improvements towards a more robust and ecologically conscious agricultural and food system may occur. On the other hand, issues including price, scalability, and regulatory compliance must be resolved. Future generations will benefit from a healthier, more environmentally conscious food and agriculture system if investments are made in this sector, which can result in a more resilient, sustainable, and food-secure planet.

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ORGANIC FARMING OF MULTIPLE CROPS - A VALUABLE WAY TO ENSURE SUSTAINABILITY AND PROFITABILITY

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Introduction

Market led cultivation of various types of horticultural and agricultural crop in a confined area is considered to be a high returned agri-business. The present case study was documented for Organic farming of Multiple crops *viz.*, Tuber, Vegetables, Fruits, Cereals and other crop adopted by a farm women under the technical guidance of KVK, Kallakurichi (Villupuram II) at Moongilpadi village, Chinnasalem block of Kallakurichi District, Tamil Nadu, India. Smt.P.Sumathi, w/o. Late. A.Palanisamy is doing agriculture since 2010 and practiced vegetable cultivation and cereals in conventional pattern. She cultivated either vegetable/cereals as a monoculture in an area of 4.26 acre. She observed plants of the similar species compete for the same nutrients and become an attractive habitat for pests of that plant and in turn poor yield and return. She also noticed soil nutrient depletion in that cultivation system. Apart from these, she faced poor returns due to market fluctuation and huge arrival of the same type of vegetable/cereal at that time. Hence she switched over to organic farming of various kind of crop, a positive and remunerative cultivation system and providing good returns under the technical guidance of KVK, Kallakurichi.

Process and methods through which interventions by KVKs was made

Organic farming of multiple crops has emerged as a promising solution, offering a holistic approach to cultivation that not only enhances crop yields but also fosters ecological sustainability. KVK promotes organic farming of multiple/various kinds of crops particularly with seasonal vegetables, fruits, tuber and other crops in the same field under drip irrigation to get sustainable income by daily/weekly/monthly and yearly basis through various on/off campus training, capacity building programmes, exposure visits to organic farming unit and demonstrations on new variety of crops and organic input production since 2019 and also facilitates to avail various state government schemes *viz.*, Construction of vermicomposting unit for the production of vermicompost as well as installation of drip irrigation under NADP/RADP programmes implemented by State Department of Horticulture.

	
Yield performance of OFT on Chilli in Tmt.Sumathi field	Demo on IIHR Vegetable foliar spray in FLD demo plot of Mrs.Sumathi
	
Radio talk at AIR,Pudhucherry	Vermicompost and organic input production
	
Inspection of organic inputs produced at Mrs.Smuathi's farm by Agriculture Officer from Department of Seed and Organic certification	Direct sale of produce by Mrs.Sumathi

Types of interventions made by the KVKs to address the problem

She has attended 6 on campus, off campus and three days CAT training programme on Organic farming in Agricultural and Horticultural crops at KVK and exposed to various organic farming input production units. Added she was one of the partakers of KVK mandatory activities such as OFT-Assessing the yield performance of Chilli hybrids and FLD on ICM practices in Elephant Foot Yam. Regular advisory services and field visits are also made to establish organic inputs production such as Vermicompost, Vermiwash, Panchakavya, Jeevamirth, EM bacteria and pest repellents.

Table.1.Economics of Organic farming in multiple crops

Sl. No	Crop	Variety	Area (acre)	Yield	Rate (Rs.)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
A.	**Annual crop (Tubers and Medicinal plants)**							
1.	Tapioca	White Thailand	1.5	19 t	800/ 76 kg	62300	200000	137700
2	Elephant Foot Yam	Co1	1	12.5 t	35/kg	80700	437500	356800
3	Medicinal coleus		1	Leaf & stem : 7 tonnes Tuber: 8 t	1.5/kg 30/kg	55650	10500 240000	194850
					Subtotal	**198650**	**888000**	**689350**
B.	**Seasonal Vegetables**							
4	Chilli	Co (CH)1	35 cent	Dry chilli-50 kg Green chilli-110 kg	300/kg 40/kg	5800	15000 4400	13600
5.	Ribbed gourd, Bottle gourd and Bhendi	Local variety	5 cent	2.3 tonnes	10/kg	2370	20300	17930
6.	Aggregatum onion	Co4	-	3.2t	60/kg	12480	192000	179520
					Subtotal	**20650**	**231700**	**211050**

C.	**Perennial crops (Fruit and Plantation crops)**							
7.	Banana	Red banana, Poovan, Rasthali, Monthan	200 Nos (Border crop)	80 bunches/ year	40/hand	3000	22400	19400
8.	Mango	Imampasand Neelum Sendura	3 tress (Border crop)	1 t	80/kg	7000	80000	73000
9.	Sapota	Cricket ball	2 tress (Border crop)	0.5 t	40/kg	3700	20000	16300
10.	Amla	NA7	2 tress (Border crop)	165kg	50	2600	8250	5650
11.	Coconut	WCT	50 trees	3100 nuts	10/nut	5000	31000	26000
					Subtotal	**21300**	**161650**	**140350**
D.	**Seasonal Flower crops**							
1.	Jasmine sp (Gundumalli,Jathimalli & Kakkattan),Chrysanthemum & Rose	All varieties	1 cent	10 pockets	100/day	1500	15000	13500
					Subtotal	**1500**	**15000**	**13500**
E.	**Cereals and Oilseed**							
1.	Paddy	Ponni	35	0.588t	-	3100	10000	6900
2.	Ground nut		1 acre (followed by coleus cultivation)	0.72t	3800/ 48 kg	12000	48000	36000
					Subtotal	**15100**	**58000**	**42900**
						257200	**1354350**	**1097150**

Inputs and output process

Smt.P.Sumathi adopted an organic farming practices in multiple crop cultivation in her land with annual crops like Tapioca, Elephant Foot Yam and Medicinal coleus in an area of 3.5 acres for getting annual income and Seasonal vegetables crops *viz.*, Chilli, Gourds, Bhendi and Aggregatum onion as inter crop as well as border crop in an area of 40 cent. Furthermore she also cultivates fruit crops such as Mango, Sapota, Banana, Amla, Coconut around the field and flower crops for getting daily income. In addition to that organic farming in paddy and groundnut in an area of 35 cent for realizing monthly income. She maintains 2 dairy animals and used the cowdung and cow's urine for the production of Vermicompost, Vermiwash, Panchakavya, Jeevamirth, Pest repellant and other inputs and applied the same to the various kinds of crop cultivation.

Outcomes and Impact of the intervention

Smt.P.Sumathi realized a net income of Rs.10,97,150 per year from 4.26 acre of land through cultivation of various kinds of crops in an organic way. This diversity not only boosts the overall yield but also mitigates the risks associated with a single crop focus. She applied for Organic certification to enrich market value of her produce. She directly sales the vegetables, fruits and flowers without middle men interference. Not only the money earned from cultivation helped to improve the quality of life and health of the farm family but also helped them to build asset base by repairing of their house, installation of pipe line for entire field and digging open well for irrigation purposes. She became a role model for her village and act as a resource person for various training programme conducted by Department of Agriculture and Horticulture, Kallakurichi District. She also provides radio talk and television programmes for the benefit of the farming community.

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IMPACT OF WTO ON INDIAN FISHERIES

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Abstract

The World Trade Organization (WTO) significantly impacts the global fisheries industry, including India's. This article examines how WTO agreements influence Indian fisheries, facilitating market expansion through tariff reductions and non-tariff barrier mitigation. India aligns with WTO standards, enhancing seafood quality and safety. The recent WTO Agreement on Fisheries Subsidies aims at ocean sustainability, posing challenges for Indian fisherfolk reliant on subsidies. Despite pressure to end subsidies, India advocates for differentiated responsibilities to protect small-scale fisher's livelihoods. This article underscores the intricate dynamics between trade regulations, sustainability, and socio-economic factors in India's fisheries sector under WTO oversight.

Keywords: WTO, Fisheries agreement, Subsidies, IUU fishing, SPS Agreement

Introduction

The World Trade Organization (WTO) stands as the primary global entity addressing trade regulations among nations. Central to its mission are the agreements negotiated and endorsed by a majority of the world's trading nations, subsequently ratified by their respective legislative bodies. The objective is to facilitate trade in a manner that is seamless, reliable, and unrestricted.

World Trade Organization (WTO)

The World Trade Organization (WTO) has impacted the Indian fisheries industry through various channels. Most significantly, it has facilitated expanded market opportunities for Indian fishery products worldwide by orchestrating tariff reductions and mitigating non-tariff barriers. Consequently, there has been a remarkable upsurge in exports, positioning India as one of the foremost global suppliers of fish and fishery goods. The diminished tariffs and non-tariff barriers negotiated within the framework of the WTO have been instrumental in driving this growth. They have enabled Indian seafood items to access a broader international market, particularly benefiting small and medium-sized enterprises involved in fisheries.

Moreover, India has harmonized its standards and regulations with global norms, particularly focusing on areas such as food safety, quality control, and sanitary measures, owing to the influence of the WTO's Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). Beyond purely economic dimensions, the WTO has spurred initiatives to align Indian fisheries practices with international environmental and health standards. The SPS Agreement has been pivotal in prompting India to adopt scientifically validated food safety and quality control measures, thereby enhancing the reputation of Indian seafood products in global markets.

The WTO also provides technical assistance and capacity-building support to developing nations, including India, to bolster their comprehension and implementation of WTO agreements pertinent to the fisheries sector. Furthermore, should concerns arise regarding trade practices related to fish and fishery products, India can resort to the WTO's dispute settlement mechanism for resolution. Crucially, the WTO recognizes the importance of sustainable development and environmental conservation, indirectly shaping how countries like India integrate environmental considerations into their fisheries policies, through agreements such as the Agreement on Agriculture and the Agreement on Technical Barriers to Trade (TBT).

Impact of WTO Agreement on Indian Fisheries

The WTO Agreement on Fisheries Subsidies, adopted during the 12th Ministerial Conference (MC12) on June 17, 2022, signifies a significant stride towards ocean sustainability by prohibiting detrimental fisheries subsidies, which have been a primary contributor to the widespread depletion of global fish stocks. This Agreement stands as a remarkable accomplishment for WTO members on several fronts: it marks the fulfillment of the first

Sustainable Development Goal (SDG) target through a multilateral agreement, the inaugural instance of a WTO agreement concentrating on environmental concerns, the premier comprehensive and binding multilateral accord addressing ocean sustainability, and only the second agreement achieved within the WTO since its establishment.

The recently concluded World Trade Organization (WTO) Ministerial meeting has reached an Agreement on Fisheries Subsidies, which will enact a prohibition on subsidies for Illegal, Unreported, and Unregulated (IUU) fishing and overexploited stocks. Additionally, the Agreement mandates the cessation of subsidies for fishing activities conducted on the high seas, which fall beyond the jurisdiction of coastal nations and Regional Fisheries Management Organizations/Arrangements (RFMO/As).

According to the Agreement, WTO Members are not barred from granting or maintaining subsidies to their vessels or operators as long as they refrain from engaging in Illegal, Unreported, and Unregulated (IUU) fishing. Similarly, subsidies for fishing activities targeting overfished stocks are not prohibited as long as they are aimed at restoring the stock to a biologically sustainable level.

India asserts that it maintains one of the lowest levels of fisheries subsidization despite its large population, and prides itself on being a conscientious steward of fisheries resources. Unlike some advanced fishing nations, India does not engage in indiscriminate resource exploitation. Its fisheries sector relies heavily on millions of small-scale and traditional fishers.

Therefore, India argues that WTO Members with a history of providing substantial subsidies and engaging in large-scale industrial fishing, which has contributed to fish stock depletion, should assume greater responsibilities in curbing subsidies. India suggests that such obligations should be based on principles like the 'polluter pay principle' and 'common but differentiated responsibilities'.

The Agreement aims to eradicate subsidies provided to fishing vessels or operators involved in Illegal, Unreported, and Unregulated (IUU) fishing. This regulation will serve to curb large-scale IUU fishing, which often results in the depletion of fisheries resources in coastal nations like India, significantly impacting the livelihoods of local fishing communities. Moreover, the Agreement offers flexibility by allowing subsidies related to overfished stocks to continue if efforts are made to rebuild these stocks to a sustainable biological level, thereby supporting fishing communities. Developing Countries and Least Developed Countries benefit from Special and Differential Treatment, granting them a two-year exemption from implementing disciplinary measures starting from the agreement’s entry into force.

The government subsidies provided to Indian fishermen are crucial for supporting their livelihoods through fishing activities. However, there is a push from developed members of the World Trade Organization (WTO) to eliminate such subsidies under the proposed fisheries subsidies agreement currently under negotiation.

Unlike countries like China, the European Union (EU), and the US, which provide significant annual fishery subsidies, India's subsidy contribution is relatively low, with just USD 277 million provided to small fishers in 2018. This subsidy plays a vital role in supporting the millions of fishers and their families in India, many of whom are below the poverty line.

India's fishing industry primarily consists of traditional, small-scale operations, with a large proportion of fishing crafts being non-mechanized. These practices have been in place for thousands of years and are essential for food security, employing sustainable methods and conserving marine resources.

Conclusion

The Indian government, in alignment with the advocacy of a group representing fisherfolk from various Indian states, has decided against implementing the WTO agreement on fisheries subsidies. This decision is primarily driven by the concern for protecting the interests of Indian fisherfolk, particularly those engaged in livelihood fishing. India has refused to sign any agreement that could potentially undermine the welfare of its fishing communities. The emphasis should be on regulating subsidies that target industrial fishing rather than livelihood fishing, reflecting a prioritization of local fishing communities' well-being over broader international trade agreements.

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HARNESSING THE GENETIC POTENTIAL OF INDIAN WILD RICE GERMPLASM

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Abstract

India is the reservoir of huge genetic diversity of wild rice germplasm that holds tremendous potential for developing robust and sustainable rice varieties. Wild rice has evolved over centuries and adapted to wider ecological niches. During the process of domestication, crop has retained substantial amount of genetic diversity in their wild progenitor species that presents an invaluable resources for widening the genetic base of modern rice cultivars with enhanced resistance to wide range of biotic and abiotic stresses. However, the natural habitats are seriously threatened by various human activities and change in global climatic condition leading to drastically erosion of genetic diversity of wild rice populations. Hence, it is crucial to conserve the wealth of untapped resources of Indian wild rice germplasm to unlock its genetic potential for developing resilient and high yielding rice cultivars for contributing to global food security and sustainable agriculture.

Introduction

Rice is most prominent staple food crop which influenced the culture, diets and economic of millions of people worldwide and plays vital role in the food security. For more than half of global population, mostly in Asiatic and African region, rice is the backbone of rural household. Considering its significance position, the United Nation declared the year 2004 as the "International Year of rice". In 2021, the global rice production was 789 million tonnes with China and India accounting for 52 % of the total production (FAOSTAT. 2021). India holds a significant position in terms of area and production of rice. The area of cultivation and production of rice in India is 46.38 million hectare and 130.29 million tonnes respectively with the productivity of 2.8 tonnes per hectare in the year 2021-22, this stands India second largest producer of rice in the world after China.

The wild germplasm of rice are abundant sources of genetic diversity that can be utilized to enhance the production and quality of rice cultivars. Since, the wild progenitors have survived for thousands of years in nature and adapted to harsh environmental conditions like floods, droughts, saline soils, and acidic soil, they must have retained wide range of genes responsible for enhancing hybrid rice production and resistance to various biotic and abiotic stresses (Brar and Khush, 1997). Genes of wild crop serve as key source for widening the genetic base of modern rice varieties (Tanksley and McCouch, 1997). Few examples of wild rice genes that have been introgressed into cultivated rice include resistance to the brown plant hopper, bacterial leaf blight, and grassy stunt virus, as well as cytoplasmic male sterility and characteristics associated with heat and drought (Khush *et al*., 1997; Sanchez *et al*., 2013).

Genetic variation and gene pools of rice

Rice is one of the most important cereal crops where approximately 120,000 distinct accessions of rice have been reported (Das *et al*., 2013). Out of 24 species of the genus *Oryza*, 22 are wild and two are cultivated species namely *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). From the 22 wild species, *O. rufipogon* Griff. and *O. nivara* are of common occurrence in India (Sharma and Shastry, 1965). The Asiatic rice (*O. sativa*) is produced around the world, while the African rice is exclusive to West Africa. Hence, it suggested the cultivated rice might have two centres of origin i.e., West Africa and Southeast Asiatic region (Patra *et al*., 2003).

Based on the ease of hybridization and phylogenetic relationship, wild relatives of rice are categorized into 3 gene pools (Harlan and de Wet, 1971). The primary gene pool consists the *O. sativa* complex (AA) with close relatives of cross-compatible rice and a secondary gene pool comprising of *O. officinalis* complex (BB to FF) with less closely related species and a tertiary gene pool constituted with O. *meyeriana* complex, *O. ridleyi* complex, and *O. schlechteria* complex (GG to KKLL genomes) with more distant relatives of rice (Solis *et al*., 2020).

According to International Rice Gene bank Collection Information System (IRGCIS) total of 4645 accession of wild rice species have been reported in the International Rice Research Institute (IRRI) Gene Bank, among which 838 are of Indian origin (http://www.irgcis.irri.org/). In India, there are 307 accessions of *Oryza rufipogon* and *726 accessions of Oryza nivara* have been reported at the National Bureau of Plant Genetic Resources (NBPGR) (http://www.nbpgr.ernet.in:8080/PGRPortal/). The genetic diversity present in these wild rice varieties is a valuable resource for breeding programs aiming to enhance the adaptability and resilience of cultivated rice.

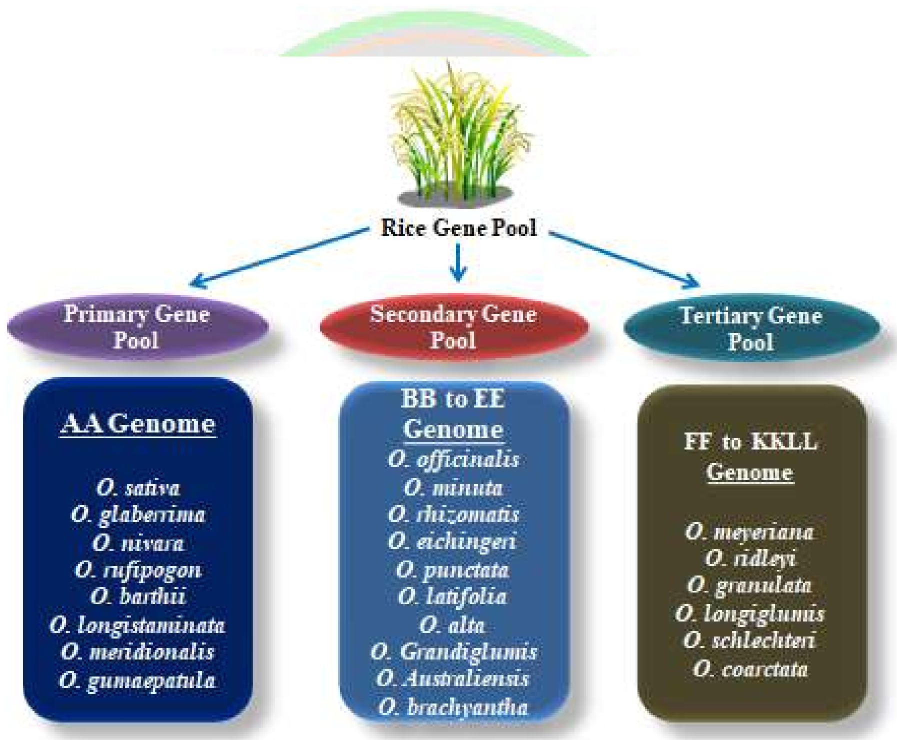

Figure 1 Gene pools of rice and its related species.

Genetic potential of wild rice germplasm accessions

Wild rice is known for its ability to withstand environmental stresses such as drought, floods, and soil salinity, traits that are essential for sustainable agriculture in the face of changing climatic conditions. The importance of wild accession of rice have been described by various studies as listed in Table 1.

Table 1: Identification of genes from wild rice accession for quantity and qualtiy improvement in rice

Sl. No.	Name of Gene	Associated Trait	References
1	Xa-21 gene	Bacterial leaf blight resistance	Khush *et al.*, 1990
2	Pi-9, Pi-40, Pi-1, Pi-54 gene	Blast resistance	Amante-Bordeos *et al.*, 1992 & Jeung *et al.*, 2007
3	L-myo-inositol 1-phosphate synthase gene	Salt tolerance	Das-Chatterjee *et al.*, 2006
4	SKC1 gene	Salt tolerance	Ren *et al.*, (2005)
5	Rc gene	Red pericarp	Sweeney *et al.*, (2006)
6	CKX1 gene	High grain number	Ashikari *et al.*, (2005)
7	GS3 gene	Grain length	Takano-Kai *et al.*, (2009)
8	BADH2 gene	Fragrance ofrice	Chen *et al.*, (2008)
9	GBSS1 gene	Grain quality	Baba *et al.*, (1993)
10	Sub1 gene	Submergence tolerance	Xu *et al.*, (2006)

Characterisation and conservation of wild rice germplasm

Wild rice is one such ancient ancestor that is distributed over the different geographical region and serves as gold mines for several agronomically important traits. Effective utilization of the wild rice in breeding program is cumbersome. Development of molecular marker based genotyping platforms; 6K SNP, 44K SNPS, 50K SNP chips and cheaper GBS - genotyping by sequencing technology as a molecular breeding tool make the crop improvement programme facile. The indigenous 50K genic SNP chip has been developed with genomic information of various rice germplasm accession (Singh *et al.*, 2015). These tools have been successfully utilized for biotic and abiotic stress tolerance programme in rice.

Systematic exploration, collection and conservation of wild rice varieties are necessary to harness the genetic potential of Indian wild rice germplasm. Gene banks are essential to preserve the diverse genetic resources for future use and successful conservation of wild germplasm requires cooperative efforts between agricultural research institutions, universities, and local communities. To study the genetic makeup of wild rice varieties researchers are exploring the genetic composition of wild rice using advanced molecular techniques, such as genomics and marker-assisted breeding that enable identification of candidate genes associated with desirable traits (Tripathy *et al*., 2018; Singh *et al*., 2018). New rice varieties with improved agronomic traits can be developed by introducing genes of wild rice crop into the cultivated varieties. In order, to harness the genetic potential of wild rice accessions for soil salinity, around 600 wild rice accessions were collected from different agroclimatic zone of India and screened for salinity tolerance (Singh *et al*., 2016; Mishra *et al.*, 2016). Identified Oryza nivara accession has been used for mapping and introgression of salinity tolerance in rice (Kumari *et al*., 2021).

Conclusion and future prospective

The genetic potential of Indian wild rice germplasm is an invaluable resource for sustainable agriculture that holds the key to addressing the challenges confronting modern agriculture. Harnessing genetic potential of wild rice germplasm is pivotal for developing rice cultivar with enhanced productivity and resilient to various biotic and abiotic stresses. Establishing and maintaining gene banks, coupled with collaborative initiatives involving agricultural research institutions and local communities, are essential for ensuring the long-term viability of these genetic resources. Integrating conventional breeding programmes with knowledge gained from genetic makeup of wild rice using genetic engineering can accelerate the production of high-yielding, climate-resilient rice cultivars that holds the promise of revolutionizing global food security.

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MOBILE APPS IN AGRICULTURE AND ALLIED SECTORS

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Introduction

The massive use of smartphones and the dynamic growth of combined mobile communications have completely transformed the daily lives and professional practices of citizens. As we know agriculture sector is mainly an important base of the economy. Agriculture as a business sector fulfils the food needs of the population of the whole world, hence agriculture is considered as the pillar of the economy. However, the level of development of mobile apps in agriculture is quite limited as compared to other business sectors, as there is less awareness about digital education in rural communities. But in the coming times, awareness will also increase in rural areas about digitization, which will make it easier to use mobile apps, so that farmers will be able to get solutions to agricultural problems on mobile in less time. Through these agriculture apps, it becomes very easy to buy and sell the agriculture market (like products and commodities) at reasonable prices. Apart from this, mobile agriculture apps provide various types of services such as meteorological information for farmers, weather forecast, agriculture news, information on modern agricultural equipment, current, fair market price, agricultural product management, dairy business information, irrigation, and proper fertilizer management, monitoring of agricultural produce, registration and enumeration of soil types and appropriate agricultural advice, etc

Agriculture professionals are coming from time to time with the latest technology and latest agricultural knowledge so that by giving technical information to the farmers, their skills can be increased. so that their knowledge can be enhanced. Through this information, farmers are not only able to increase their efficiency but also increase their production by reducing their agricultural costs. Agriculture professionals are playing an important role in the development of farmers. These professionals conduct research to help them make financially sound crop management decisions. But digitization is very important for disseminating the latest information on agriculture among the farmers. At present, there are many agriculture apps in India that provide technical assistance to farmers. This agriculture app is very useful for Indian farmers, cattle ranchers, and rural farming communities. This agriculture app keeps you updated with the latest technical information on agriculture. These apps fill the information gap between rural people and the government along with rural development.

Farmers can directly ask the agriculture scientists or consultants to solve their agriculture-related problems through these apps and can get the solutions immediately. Along with this, farmers can also share their experiences and discussions about the crop through this app by forming a digital group. Apart from this, these apps also provide farmers with new technical information and videos of successful farmers. In this way, farmers can also acquire knowledge from time to time through videos.




The app is very easy to use and provides a user-friendly interface. It provides information about current weather information and weather forecast for next 5 days, commodity market price, fertilizers, seeds, machinery etc. The main feature of this app is that the user can select any language according to his convenience and get information.

2. IFCO Kisan Agriculture App

The main objective of this app is to provide timely information to Indian farmers as per their requirement. In addition, users can access various informational modules including Agriculture Advisory, Weather, Market, Price, Agriculture Information in the form of text, image, audio, video in selected language at the profiling level. The main feature of this app is that it also provides helpline numbers for farmers to contact Kisan Call Center services. Therefore, through the helpline number, farmers can also get the solution of their agricultural problems.

3. RML-Farmers Krishi Mitra App

It's a very useful farming app where farmers can keep up with the latest commodity and mandi prices, balance usage of pesticides and fertilizers, farm and farmer-related news, weather information, weather forecast, and advisory services. not only this, it also provides agricultural advices and news regarding the government's agricultural policies and schemes. It is designed with precise tools to investigate or offer facts on exclusive factors of farming behavior.

4. Crop Insurance App

This app is highly useful for insurance farmers. This app provides information to the insurance farmers about the calculation of insurance premium and cutoff dates for the notified crops. This insurance acts as a calculator remembrancer for the farmers about their insurance.

5. Kheti-Badi App

Kheti-badi App is very popular and highly used app among farmers. The main feature of this app is to make farmers aware about organic farming, promoting organic farming and supporting organic farming. the main objective of this app is to encourage farmers to leave chemical farming and adopt organic and sustainable farming. So that we can produce pure quality products without harming the soil and environment.

6. PUSA Krishi App

PUSA Krishi is a government app that was launched in the year 2016 by the Union Agriculture Minister. the app gives the information about

- Indian Agriculture Research Institute's (IARI) technologies for agriculture.
- Indian Council of Agricultural Research (ICAR) new crop varieties.
- Practices on resource-conserving cultivation and farm machinery.

7. Agri App

This app provides complete information to the farmers about the following.

- Crop Production
- Protection and Information on “High value, low product”.
- Interaction with experts over a chat.
- Online markets for fertilizers, insecticides, etc.

8. Agri-Market App

This app has been developed to provide marketing related information to the farmers. This app has been designed with an aim to make farmers aware of crop prices and reduce the risk of going for distress sales.

9. Krishi Gyan App– Through this app, farmers ask their questions to experts.

Krishi Gyan is software aimed at providing agricultural statistics to rural, farming audiences. This software will allow Indian farmers to connect with Krishi Gyan experts, ask their farming questions, and get the answers inside the software through notification. The farmers and agriculture enthusiasts can also share their responses.

10. Crop Insurance App – Helps farmer to calculation of insurance premiums for notified crops.

Crop insurance is a farmer mobile app that can calculate the insurance premium for notified crops based on area, coverage amount and loan amount in the case of a loanee farmer. It also provides the details of the standard sum insured, premium details, subsidy information and extended sum certified of any notified crop in any notified area.

11. AgMOOCs App –

- It is an online platform created to support professionals, students, and organizations in improving and acquiring knowledge in the agriculture domain.
- It gives free access to various high-quality courses online offered by renowned faculty from the country’s premier institutes.
- The purpose is to reach out to thousands of scholars, thus enabling them to obtain higher agricultural education.

12. Agri App

It is one of the most liked apps by the farming community. It is an online farming marketplace bringing Kisan, farming input/output, government service on an online platform. It also provides chat option for farmers. the main feature of this app is that farmers can get information by chatting with Agri experts.

13. Plantix App

It is also one of the most liked apps by the farming community. Plantix is a mobile crop advisory app for farmers, gardeners and extension workers. The app provides facility to diagnose pest damages, plant diseases and nutrient deficiencies affecting crops and offers corresponding treatment measures.

14. MKisan Application App

This app is extremely easy to use. It is an Android app that allows farmers and all other stakeholders to get advice and information being sent by experts, scientists and government officials at various levels through the **Mkisan** portal without registering on the portal.

15. Soil Health Card (SHC) Mobile App

A Soil Health Card gives soil nutrient status to each farmer for his/her land holding and also gives advice on fertilizer dosage and soil amendments needed to maintain soil health in the long run. Soil Health Card will be issued to all landholders every three years and this will enable capture of the pattern of soil fertility changes occurring due to nutrient uptake by plants or other natural causes. Through this app, it will be helpful to find ways to overcome the deficiency of nutrients which have been identified in the soil Health Card, so that we can improve the health of the soil.

16. eNAM Mobile App

National Agriculture Market (NAM) is a pan-India electronic trading portal promoted by Government of India which networks the existing mandis to create a unified national market for agricultural commodities. The purpose of the Mobile App is to facilitate remote bidding by traders and access to arrivals and price related information to farmers and other stake holders on their smart phones.

17. Digital Mandi India

This App helps in checking the latest Mandi prices of agricultural commodities reported from different states and districts/mandis in India. One can get commodity wise categorization or state wise categorization.

18. AgroStar App

Farmers across India are now discussing their farming questions with AgroStar Agri-Doctor and fellow farmers. The main feature of this app is that this app allows farmers to post their asking questions in the form of video, images, and text in their local languages.

21. Bharat Agri App

Bharat Agri app is a Smart Kisan & Smart Farming App for Farmers using all-new Agri tech solutions (Kheti Badi) with the help of available technology like Smart Satellite Mapping, Weather Forecasting, Soil Testing, and Water Testing to increase farmers overall farm income.

22. WhatsApp

It may come off as a surprise to many, but one of the most widely used app for texting is bridging gaps between farmers. Departments of Agriculture of a few states have used this public platform to make groups called Progressive Farmers' which connects sons of the soil through their android devices. At present, farmers of different states also connect with each other by creating WhatsApp groups and share information about crops, so that the level of their knowledge increases. So, this facility is easily available to them on WhatsApp app.

23. Kheti-Badi

'Kheti-Badi' is a social initiative app that aims to promote and support 'Organic Farming' and provide important information/issues related to farmers in India. This app helps farmers to switch their chemical farming to organic farming. However, this app is currently only available in four languages(Hindi, English, Marathi, and Gujarati).

Conclusion

Farmers' apps have become the best solution to overcome farming challenges. Also, with these apps, farmers can now easily know what's the best way to produce crops at best-selling rates, backed by best-farming machinery options and popular Government schemes. Furthermore, these convenient apps help farmers resolve every tiny to the big query they may have regarding their farm and farming practices specifically. So bookmark or start downloading the above apps for agriculture, as they are owned by trusted agro experts and have easy-to-use interfaces and language options.

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AGRI-ENTREPRENEURSHIP IN INDIA: A RECOGNIZED TOOL FOR DRIVING ECONOMIC DEVELOPMENT IN THE NEW MILLENNIUM

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Abstract

In India, where agriculture contributes around 25 per cent to the gross domestic product, the challenge of rural-to-urban migration persists due to limited job opportunities and inadequate rural infrastructure. There is a need to uncover the untapped opportunities in agriculture for local entrepreneurs, which are essential for improving overall well-being. Shifting from traditional agriculture to agribusiness is crucial for revitalizing Indian agriculture and making it more profitable. Agripreneurship offers significant potential for social and economic development, including employment creation, income generation, poverty reduction, and improvements in nutrition and food security. It also has the capacity to spur growth, diversify income, and create entrepreneurial opportunities in rural areas. This article focuses on the core concepts of agripreneurship, necessary entrepreneurship skills and the key factors driving its development in India. Moreover, it delves into the key factors influencing economic development in both rural and urban areas, examining various agricultural opportunities and developing a predictive model for sustainable economic growth through agricultural entrepreneurship in the new millennium.

Introduction

India manages 2.4 per cent of the world's landmass while accommodating 17.5 per cent of the global population. Following independence, agriculture contributed more than half of the national income, with over 70 per cent of the population relying on it (Pandey, 2013). Agriculture and its related sectors are pivotal to India's economy as they serve as crucial sources of raw materials for industries and drive demand for various industrial products like fertilizers, pesticides, and agricultural tools (Bairwa et al., 2014). Given the evolving socio-economic, political, environmental, and cultural landscapes worldwide, the adaptability of farmers and nations to ensure sustainable success has become increasingly imperative. The rise of free-market economies globally has nurtured a fresh entrepreneurial ethos known as "Agrientrepreneurship," reflecting a growing individual inclination towards assuming responsibility for their businesses (Alex, 2011).

Entrepreneurship, including its agricultural variant, entails establishing and cultivating profitable farm enterprises. Dollinger (2003) characterizes entrepreneurship in agriculture as the creation of innovative economic entities aimed at growth or profit amidst risk and uncertainty within the agricultural domain. Amidst rising unemployment and poverty in rural areas and the sluggish pace of agricultural development, there arises a critical need for entrepreneurial endeavors within agriculture to boost productivity and profitability. It is essential to introduce Agripreneurship programs aimed at cultivating entrepreneurs and skilled management personnel to meet the demands of the global agricultural sector (Bairwa et al., 2014). The dynamics of Agripreneurship are primarily influenced by economic circumstances, educational levels, and cultural factors (Singh, 2013).

Need of Agri-entrepreneurship development in India

- Since the introduction of the New Economic Reforms between 1992 and 1995, characterized by the adoption of liberalization, privatization, and globalization (LPG) policies, as well as the establishment of the World Trade Organization (WTO), there was an anticipation that rural areas would progress in parallel with urban centers.
- The performance of agriculture during the initial phase of economic reforms until 1998 served as a driving force behind this expectation across academia, administration, and government circles (Singh, 2013).
- However, subsequent years witnessed a deviation from this trajectory, with agricultural performance falling short of expectations. Previously, agriculture was often perceived merely as land cultivation and crop harvesting. However, factors such as the expansion of wasteland, depletion of natural resources, increased rural-to-urban migration among youth, negative perceptions of farming among farmers' children, and the introduction of new agricultural technologies have necessitated a redesign of agricultural practices.

- Implementing entrepreneurial principles in agriculture can yield various economic benefits, including enhanced agricultural productivity, the establishment of new business ventures, job creation, the development of innovative products and services, rural area development, and wealth generation.
- Traditional farmers lacking knowledge of modern agricultural techniques and effective management systems struggle to cope with challenges such as delayed monsoons, drought, crop debts, counterfeit seeds, and fertilizer shortages, often resulting in suicides.
- By applying managerial, technical, and innovative entrepreneurial skills in agriculture, positive outcomes can be achieved, with well-trained agripreneurs potentially serving as role models for disillusioned farmers.
- Sah (2009) suggests that fostering entrepreneurship in agriculture can address multiple issues, including reducing the burden on agriculture, creating employment opportunities for rural youth, curbing rural-to-urban migration, boosting national income, supporting industrial development in rural areas, and alleviating pressure on urban cities.

Reasons for promoting Agripreneurship in India

- In India, around 52 per cent of the total land is arable, which is significantly higher than the global average of 11 per cent. The country encompasses all 15 major climatic zones found worldwide, ranging from the snow-covered Himalayas to the hot and humid southern peninsula, as well as diverse regions such as the Thar desert and areas with heavy rainfall. With 20 agro-climatic regions and nearly 46 out of 60 soil types, India boasts favorable conditions for year-round crop cultivation, thanks to ample sunshine hours and an ideal day length.
- India serves as a hub for biodiversity, hosting a vast array of plant, animal, insect, and microorganism species, accounting for approximately 17 per cent of animal genetic resources, 12 per cent of plant genetic resources, and 10 per cent of fish genetic resources globally.
- In the livestock sector, India holds substantial shares, including 16 per cent of the world's cattle, 57 per cent of buffalo, 17 per cent of goats, and 5 per cent of sheep populations. Agriculture plays a crucial role in India's economy, contributing 13.2 per cent to the GDP, 15.2 per cent to total exports, and employing 58.4 per cent of the workforce (Mittal, 2009).

- Agriculture remains a cornerstone of the Indian economy, with a significant contribution to GDP and export earnings. India ranks among the top producers globally in various crops, including rice, wheat, pulses, and coarse grains, and is a leading producer of commodities like cotton, sugar, sugarcane, peanuts, jute, tea, and spices. Despite its importance, there is room for growth and improvement in the agricultural sector, with a need for a multifaceted strategy to enhance its performance.
- In recent years, there has been a notable shift towards crop diversification, particularly in horticulture, plantation crops, and allied activities. The development of critical infrastructure, such as cold storage, refrigerated transportation, rapid transit, processing facilities, and quality control measures, presents significant investment opportunities.
- India ranks second in fruit and vegetable production globally, yet only 10 per cent of the produce is covered by cold storage facilities. Additionally, investments in the cold chain are essential to address the storage needs for surplus meat and poultry products.
- Given these factors, the transformation of Indian agriculture into agribusiness is imperative, and this transition can be facilitated through the development of agripreneurship.

Role of Agrientrepreneurship in Economy and possible areas

Agripreneurship serves as a catalyst for the growth and advancement of the national economy by promoting entrepreneurship, leading to increased income levels and job opportunities in both rural and urban regions (Bairwa et al., 2012). Furthermore, agripreneurship plays a vital role in various aspects of the economic system, as elucidated:

- Enhancing Productivity: Agripreneurship initiatives drive productivity gains among smallholder farmers by introducing innovative techniques, technologies, and market integration strategies. This not only improves agricultural output but also empowers farmers to access broader markets, thereby bolstering their economic prospects.
- Mitigating Food Insecurity: Agripreneurship contributes to reducing food costs and supply uncertainties by optimizing production, distribution, and marketing processes. By ensuring a steady and reliable food supply, agripreneurs play a crucial role in enhancing food security and nutrition, particularly for marginalized rural and urban populations.
- Fostering Economic Growth: Agripreneurship stimulates economic growth by attracting investment, fostering innovation, and diversifying income streams within the agricultural

sector. By establishing new businesses and expanding existing ones, agripreneurs generate employment opportunities and drive economic development in both rural and urban areas.

- Promoting Sustainable Agriculture: Agripreneurship encourages the adoption of sustainable farming practices that prioritize environmental conservation, resource efficiency, and resilience to climate change. Through initiatives such as organic farming, agroforestry, and water conservation, agripreneurs contribute to long-term agricultural sustainability and resilience.
- Empowering Rural Communities: Agripreneurship empowers rural communities by providing them with the knowledge, skills, and resources to harness their agricultural potential. By fostering entrepreneurship and innovation at the grassroots level, agripreneurship initiatives enable rural residents to create economic opportunities, improve livelihoods, and reduce dependency on traditional agricultural practices.
- Facilitating Rural-Urban Linkages: Agripreneurship bridges the gap between rural and urban economies by facilitating value addition, processing, and marketing of agricultural products. This not only creates market opportunities for rural producers but also strengthens supply chains, promotes rural-urban trade, and fosters economic integration between rural and urban areas.
- Promoting Technological Innovation: Agripreneurship drives technological innovation and adoption within the agricultural sector, leading to improved efficiency, productivity, and sustainability. By investing in research and development, agripreneurs harness the power of technology to address agricultural challenges, optimize resource utilization, and enhance competitiveness in domestic and global markets.
- In essence, agripreneurship plays a multifaceted role in driving economic development, promoting food security, fostering sustainability, empowering rural communities, facilitating rural-urban linkages, and promoting technological innovation within the agricultural sector. By leveraging entrepreneurship and innovation in agriculture, agripreneurs contribute to building a more prosperous, resilient, and equitable society.

Possible areas for agri entrepreneurship development:

Entrepreneurship in agriculture encompasses various ventures, as detailed by Pandey (2013), including dairying, sericulture, goat rearing, rabbit rearing, floriculture, fisheries, shrimp farming, sheep rearing, vegetable cultivation, nursery farming, and farm forestry. The distinct areas of entrepreneurial activity within agriculture are as follows:

- Agro Produce Processing Units: These entities focus on processing agricultural produce rather than manufacturing entirely new products. Examples include rice mills, dal mills, and decorticating mills, which play a crucial role in adding value to raw agricultural commodities.
- Agro Produce Manufacturing Units: In contrast, manufacturing units utilize agricultural produce as raw material to create entirely new products. Sugar factories, bakeries, and strawboard units exemplify this category, contributing to product diversification and value addition within the agricultural sector.
- Agro-Inputs Manufacturing Units: These establishments produce goods essential for mechanizing agriculture or enhancing productivity. Examples include fertilizer production units, food processing units, and agricultural implement manufacturing plants, supporting agricultural modernization and efficiency.
- Agro Service Centers: These facilities provide workshops and services for repairing and maintaining agricultural implements used in farming operations. By ensuring the proper functioning of machinery and equipment, these centers support farmers in optimizing agricultural practices and productivity.
- Miscellaneous Areas: Beyond the aforementioned categories, numerous other opportunities exist for agri-enterprises. These include apiaries for beekeeping, feed processing units, seed processing units, mushroom production units, commercial vermicompost units, goat-rearing farmers' clubs, organic vegetable and fruit retail outlets, bamboo plantation, and jatropha cultivation. These diverse ventures contribute to the overall development and sustainability of the agricultural sector while offering entrepreneurial opportunities in niche markets and value chains.
- In summary, agriculture-based entrepreneurship spans a broad spectrum of activities, each contributing to the growth, diversification, and sustainability of the agricultural economy. From processing and manufacturing to service provision and niche enterprises, these entrepreneurial ventures play a vital role in adding value to agricultural produce, enhancing productivity, and meeting diverse market demands.

Conclusion

Entrepreneurship within the agricultural sector encompasses a diverse range of activities, each contributing to the overall growth and development of agriculture as an industry. These activities include processing, manufacturing, service provision, and specialized ventures. Agricultural produce processing units and manufacturing units play a crucial role in adding value to raw agricultural commodities. Processing units focus on transforming raw agricultural products into processed goods, such as rice mills converting paddy into polished rice or dal mills processing pulses. On the other hand, manufacturing units create entirely new products using agricultural produce as raw materials. Examples include sugar factories utilizing sugarcane to produce sugar or bakeries using wheat flour to make bread. These units contribute to product diversification and value addition within the agricultural sector, making the products more marketable and profitable. Agro-inputs manufacturing units produce essential goods necessary for mechanizing agriculture or enhancing productivity. This category includes the production of fertilizers, pesticides, agricultural machinery, and other inputs crucial for farming operations. By supplying quality inputs, these units support agricultural modernization and efficiency, helping farmers improve yields and optimize their production processes. Agro-service centers offer workshops and services for repairing and maintaining agricultural implements used in farming operations. These centers play a vital role in ensuring the proper functioning of machinery and equipment, which is essential for farmers to optimize their agricultural practices and productivity. By providing timely maintenance and repair services, these centers contribute to minimizing downtime and maximizing the efficiency of farming operations. In conclusion, entrepreneurship in agriculture encompasses a wide array of activities, each playing a crucial role in driving the growth, diversification, and sustainability of the agricultural economy. From adding value to agricultural products through processing and manufacturing to providing essential services and exploring niche ventures, entrepreneurship is instrumental in propelling the agricultural sector forward. Overall, these entrepreneurial endeavors contribute to enhancing food security, rural development, and economic prosperity.

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A HUNGRY CATERPILLAR: MAIZE FALL ARMYWORM (*Spodoptera frugiperda*)

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Introduction

Maize fall armyworm (*Spodoptera frugiperda*) was first reported in Africa in 2016, which cause significant damage to maize crops and has great potential for further spread and economic damage. In 2018, it began to spread widely in India. In January 2019, heavy infestation of fall armyworm was recorded from corn plantations of Sri Lanka.

Systematic Position

Domain: Eukaryota
Kingdom: Animalia
Phylum: Arthropoda
Sub-phylum: Uniramia
Class: Insecta
Order: Lepidoptera
Super family: Noctuoidea
Family: Noctuidae
Genus: *Spodoptera*
Species: *S. frugiperda*
Binomial Name: *Spodoptera frugiperda*

Facts about Fall Armyworm

- **A hungry caterpillar:** It’s not a worm. It’s a caterpillar that grows and transforms into a moth. This means it can travel far once it reaches the adult stage

- **A travel lover:** The adult moth can travel over 100 kilometers per night and with the help of a good wind and it has been known to travel more than 1000 kilometers in 30 hours
- **An egg laying machine:** 1000's of eggs per female. In adult stage, the fall armyworm will reproduce quickly

Symptoms of damage

- Young larvae scrapped the chlorophyll content on the leaf surface
- Older larvae feeds upon the central whorl and cause extensive defoliation
- It also feeds the whorl, tassel and cob

Young larva scraps the chlorophyll content **Damaged central whorl**

Economic Threshold Level (ETL)

In maize, if 5% of seedlings are cut (or) 20% of whorls of small plants (during first 30 days) are infested, it is the correct time to prevent the damage and recommended that an insecticide to be applied

Pest Identification

Egg

- Eggs are laid in masses (120-150 eggs/ egg mass) and covered with scales or with tuft of anal hairs to prevent it from predators attack

Larva

- Larva with 4 black spots arranged in square shape on the 8th and 9th abdominal segment
- Larvae with inverted "Y" shaped marking on head

Larva with 4 black spots **Inverted "Y" shaped marking**

Pupa

- Pupation normally takes place in soil at a depth of 2 to 8 cm
- The larva constructs a loose cocoon which is oval in shape by tying together soil with silk
- If the soil is too hard, larvae may web together the leaf debris and other material to form cocoon
- Pupa is reddish brown in colour

Adult

- Adults are nocturnal and are most active during warm and humid evenings
- In male moth, the forewing is shaded with grey and brown with triangular white spots at the tip and near the centre of the wing
- The forewings of females are less distinctly marked, ranging from a uniform grayish brown to a fine mottling of grey and brown

Male moth

Female moth

Management

- Apply neem cake @ 250 kg/ha at the time of last ploughing
- Seed treatment with cyantraniliprole 19.8% + thiamethoxam 19.8% FS @ 4 ml/kg seed
- Border cropping with cowpea, gingelly, redgram or sunflower (garden land) and fodder sorghum (dry land) @ 3 rows
- Set up FAW pheromone traps @ 12 nos./ha
- Spray azadirachtin 1500 ppm @ 2.5 lit/ha or chlorantraniliprole 18.5 SC @ 200ml/ha (or) flubendiamide 480SC @ 250ml/ha at early stage (15 - 20 DAE)
- Spray *Metarhizium anisopliae* (TNAU-MA-GDU isolate) @ 2.5 kg/ha or emamectin benzoate 5 SG @ 200g/ha or novaluron 10 EC @ 750 ml/ha or spinetoram 11.7 SC @ 250 ml/ha at late whorl stage (35 - 40 DAE)
- One of the insecticides recommended in late whorl stages can be used at cob formation stage if needed, but repetition to be avoided

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OPTIMIZING FEED EFFICIENCY IN LIVESTOCK PRODUCTION FOR ECONOMIC AND ENVIRONMENTAL

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Abstract

Livestock production is a cornerstone of global food security but faces mounting pressure to become more economically and environmentally sustainable. Feed costs typically comprise the largest expense in animal production, and inefficient feed conversion translates to wasted resources, increased greenhouse gas emissions, and pollution. This article explores strategies for optimizing feed efficiency in livestock production, examining the economic and environmental benefits it brings. We will delve into dietary modifications, improved management practices, and advancements in animal breeding and nutrition science. By implementing these strategies, livestock producers can achieve significant cost savings, reduce their environmental footprint, and contribute to a more sustainable food system.

Keywords: Livestock production, Precision farming, Sustainable livestock production, Animal nutrition, Feed efficiency

Introduction

The global demand for animal protein is projected to rise steadily in the coming decades, driven by population growth and increasing affluence. While livestock production plays a vital role in food security and nutrition, it also faces the challenge of becoming more sustainable. Livestock production is a major consumer of resources, with feed representing up to 70% of the total production cost. Inefficient feed conversion, where animals consume more feed than necessary to achieve desired growth or milk production, translates to a significant economic burden for producers and environmental consequences for the planet.

Economic Benefits of Improved Feed Efficiency

Optimizing feed efficiency offers a win-win scenario for livestock producers and the environment. Here's how:

- **Reduced Feed Costs:** Feed is the single largest expense in livestock production. By improving feed efficiency, producers can significantly reduce their overall production costs, leading to higher profit margins. Studies have shown that even marginal improvements in feed conversion ratio (FCR) can translate to substantial cost savings.
- **Enhanced Farm Profitability:** Improved feed efficiency directly translates to increased profitability for farms. With less feed required to achieve production goals, producers can either reduce feed expenditure or maintain output while lowering overall costs. This allows for reinvestment in farm improvements and contributes to the long-term sustainability of the operation.

Environmental Benefits of Improved Feed Efficiency

Livestock production contributes to environmental concerns such as greenhouse gas emissions, water pollution, and land-use change. Improving feed efficiency can mitigate these impacts in several ways:

- **Reduced Greenhouse Gas Emissions:** Less feed translates to a smaller environmental footprint. Animals with improved feed efficiency produce less methane, a potent greenhouse gas, per unit of product output. This contributes to mitigating climate change impacts associated with livestock production.
- **Lower Water Consumption:** Feed production requires significant water resources. By reducing overall feed consumption, optimized feed efficiency leads to a decrease in the water footprint of livestock production. This is particularly crucial in regions facing water scarcity.
- **Conservation of Land Resources:** Inefficient feed utilization requires more land for feed production. Improved feed conversion ratios allow for the production of the same amount of animal protein with less feed, thereby reducing pressure on land resources and deforestation associated with feed crop cultivation.

Strategies for Optimizing Feed Efficiency

Several key strategies can be implemented to improve feed efficiency in livestock production:

- **Dietary Modifications:** Optimizing feed formulations to meet the specific nutritional needs of different animal types and life stages plays a crucial role. This may involve incorporating high-quality forages, utilizing feed additives that enhance nutrient digestibility, and exploring alternative feed sources like food waste or byproducts from other industries.
- **Precision Feeding:** Precision feeding practices involve tailoring feed rations to individual animals based on their age, weight, and production level. This ensures that animals receive the exact amount of nutrients required for optimal growth or milk production, minimizing feed waste. Technological advancements like automated feeders can facilitate precision feeding practices.
- **Improved Management Practices:** Effective management practices such as maintaining optimal animal health, controlling parasites, and providing proper housing and environmental conditions can significantly impact feed utilization. Healthy animals with minimal stress are better equipped to convert feed efficiently.
- **Animal Breeding and Genetics:** Selective breeding programs that focus on animals with superior feed conversion ratios can lead to long-term improvements in herd efficiency. Advancements in genetic selection tools like genomic testing can further accelerate this process.

Conclusion

Optimizing feed efficiency in livestock production is a crucial step towards achieving a more sustainable food system. By implementing a combination of dietary modifications, improved management practices, and advancements in breeding and nutrition science, producers can achieve significant economic and environmental benefits. Improved feed efficiency translates to reduced production costs for farmers, a smaller environmental footprint for the industry, and ultimately, a more sustainable future for food production.

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INDIA'S DIVERSE REGULATORY MECHANISM FOR SUSTAINABLE SEED CERTIFICATION IN AGRICULTURE

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Abstract

Seed certification is a pivotal component of agricultural regulation, ensuring farmers' access to high-quality seeds that meet stringent standards. National regulatory mechanisms for seed certification vary across countries, shaped by diverse agricultural practices and specific needs. Regulation in the agricultural sector is multifaceted, with objectives ranging from preventing market failures to promoting public interest and fair competition. Economic regulation strategically employs subsidies and incentives to stimulate the production and distribution of quality seeds, contributing to market efficiency. Quality control regulations ensure certified seeds meet established standards, safeguarding both seed quality and broader public concerns. Environmental regulations address the potential negative impact of seed production on biodiversity and promote sustainability. National regulatory mechanism includes acts and these acts collectively form a comprehensive approach to agricultural regulation, covering plant protection, seed quality and environmental conservation. This paper provided a comprehensive overview of the key components and acts within the Indian regulatory framework, emphasizing its significance.

Keywords: National Regulation, Seed certification, Sustainable Agriculture

Introduction

Seed certification is a crucial aspect of agricultural regulation, ensuring that farmers have access to high-quality seeds that meet established standards for purity, germination, and other important traits. The national regulatory mechanisms governing seed certification vary across countries, shaped by diverse agricultural practices, climates, and specific needs. Typically, countries enact legislation and regulations that delineate the scope, objectives, and procedures for seed certification.

A well-defined national seed policy establishes overarching principles and goals for the seed sector, emphasizing aspects like quality, diversity, and accessibility. Implementation and oversight of the certification process fall under the purview of a designated government agency, responsible for transparency and accountability. Regulations detail the production and multiplication procedures, ensuring adherence to quality standards from breeding to distribution. Field inspections and seed testing, conducted by inspectors and laboratories, respectively, verify compliance with standards.

Proper documentation, including labeling with information such as seed class and germination rate, enhances traceability and accountability. Enforcement mechanisms with associated penalties deter the distribution of substandard seeds. Public awareness programs and educational initiatives play a crucial role in fostering understanding among farmers and stakeholders about the significance of certified seeds and proper seed management practices.

Additionally, collaboration with international organizations and adherence to global seed standards are essential for countries engaged in seed trade. Farmers and seed industry stakeholders typically benefit from a robust and well-implemented seed certification system and its regulation, as it ensures a reliable supply of high-quality seeds for sustainable agriculture. However, I provided a general overview of the key components and acts that are typically included in a national regulatory mechanism, especially for seed certification:

Objectives of regulation

The objectives of regulation in markets are multifaceted, serving to prevent market failures arising from uneven or inadequate regulation. By implementing regulatory measures, authorities aim to curb anti-competitive practices, ensuring fair competition and maintaining the quality of commodities in the market channel.

This not only fosters a level playing field for businesses but also safeguards consumers from substandard products. Additionally, regulatory frameworks are designed to promote the public interest by aligning the supply of goods with the demands of the public.

This involves creating an environment that encourages economic growth, innovation, and equitable access to essential goods and services. Ultimately, effective regulation strives to strike a balance, fostering a competitive yet fair marketplace that serves the broader interests of both businesses and the public.

Typology of regulation in India

- Three main broad categories

Economic regulation plays a pivotal role in shaping the flow and dynamics of the market channel while mitigating the risk of market failure. This regulatory framework involves the strategic implementation of subsidies and various benefits for both seed producers and manufacturers. By providing targeted economic incentives, such as subsidies for certified seed production or tax benefits for adherence to quality standards, regulators stimulate the production and distribution of high-quality seeds. These measures not only encourage compliance with certification standards but also contribute to the overall health and efficiency of the seed market.

This is designed to safeguard both the quality of seeds and the broader concerns of the public. These regulations encompass stringent quality control measures to ensure that certified seeds meet established standards for purity, germination, genetic identity, and disease resistance. By setting and enforcing these standards, regulators aim to guarantee that farmers have access to seeds that will enhance agricultural productivity and contribute to sustainable farming practices.

Environmental regulation is crucial to address concerns related to the potential negative impact of seed production and distribution on the environment, including biodiversity. These regulations are designed to ensure that the seed certification process aligns with sustainable and environmentally friendly practices.

National Regulatory Mechanism (Specifically for Agriculture)

A comprehensive national regulatory mechanism for agriculture involves the establishment and enforcement of policies, laws, and standards to ensure the sustainable and efficient development of the agricultural sector. The key components of such a regulatory framework include:

Destructive Insects and Pests Act (DIPA) 1914

- Enacted as the first quarantine law in India after the British ordered compulsory fumigation of imported cotton bales to prevent the Mexican cotton boll weevil (*Anthonomus grandis*) in 1906.
- The government of India legislated the Destructive Insects and Pests Act (DIPA) in 1914. To regulate imports in order to prevent the introduction of foreign diseases, weeds, and pests.
- Later it also restricted the movement of certain planting material from one state to another within the country through the domestic quarantine in 1984.
- Restrict or outright ban imports into India or any other region. Prohibit or restrict the movement of any plants, plant materials, diseases, or insects that could spread an infection or produce an infestation from one Indian state to another.
- Authorizes the State Govt. to make rules for inspection, disinfection/disinfestations or destruction of any pest or class of pests for which center has issued notifications.

Seeds Act (1966)

- The Act was passed by the parliament in 1966 and Seed Rules were framed under it in 1968. Legislative measures propagated to ensure high quality of seed in the marketplace.
- Act provides for a system of notification of kinds or varieties of seeds. Also, this Act provides the legal framework for seed certification and establishes the process through which seeds are tested, certified, and labeled. The act establishes the National Seeds Certification Agency (NSCA) and State Seeds Certification Agencies (SSCAs) to carry out the certification process. These agencies are responsible for certifying seeds based on prescribed standards.
- Seed (Control) Order, 1983 seeks to control and regulate seed production and distribution as seed declared as an essential commodity under the Essential Commodities Act, 1955.

Insecticides Act (1968)

- This Act is an important legislation in India that governs the regulation of insecticides to ensure their safe use and distribution. The primary objective of this act is to regulate the import, manufacture, sale, transport, distribution, and use of insecticides to prevent risks to human beings and animals.

- The act mandates the registration of insecticides before they can be imported, manufactured, sold, or distributed. This process involves evaluating the efficacy and safety of the insecticide. The act provides the establishment of Pesticide Quality Control Laboratories to carry out tests on insecticides to verify their quality and adherence to standards.
- The act aims to promote the judicious use of insecticides while safeguarding the environment.

Environmental Protection Act (1986)

- Aims to protect and improve the quality of the environment. Provides for management and handling of hazardous wastes, use, import/export, hazardous micro-organisms and genetically engineered organisms.
- While the primary focus of the EPA is on addressing various environmental issues, it indirectly influences seed certification by ensuring that agricultural practices, including seed production, adhere to environmental conservation principles. The EPA regulates the use, handling, and disposal of hazardous substances. This is relevant to seed certification, as certain seed treatments and chemical applications may involve substances that are considered hazardous to the environment.
- The EPA emphasizes the conservation of natural resources, including soil and water. Agricultural activities related to seed production are expected to adopt practices that conserve soil fertility and minimize water pollution.

Regulation of Genetically Modified Organisms (GMOs)

In India, all GMOs including GM crops are regulated as per the "Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or commonly Cells" referred to as Rules, 1989 under the Environment (Protection) Act, 1986. India regulates the cultivation and release of genetically modified crops through the Genetic Engineering Appraisal Committee (GEAC) under the Ministry of Environment, Forest and Climate Change. Strict protocols are in place to assess the environmental and health impacts of GMOs before approval for commercial cultivation.

New Policy on Seed Development (1988)

- Came into force intending to provide Indian farmers with the best genetic material available anywhere in the world to increase agricultural productivity, farm income and export earnings.

- Aimed at liberalization of imports along with streamlining of plant quarantine procedures and encouragement to domestic seed industry through incentives.

Protection of Plant Varieties & Farmer's Rights Act (2001)

- The Protection of Plant Varieties and Farmers' Rights Act (2001) is an important piece of legislation in India that addresses the protection of plant breeders' rights and the rights of farmers concerning the protection of plant varieties.
- That aims to encourage the development of new varieties of plants, ensure fair returns to farmers, and promote the conservation of genetic resources.
- The act establishes a mechanism for the registration of plant varieties, allowing breeders to protect their intellectual property rights. Seed varieties covered by this act may undergo a registration process to ensure their authenticity and adherence to specified criteria. The act allows for the issuance of compulsory licenses to ensure the availability of protected plant varieties. This may have implications for seed certification, especially when it comes to making quality seeds accessible to a larger section of farmers.

Biological Diversity Act (2002)

- The main objective of this act is to conserve biological diversity, promote sustainable use of its components and ensure the fair and equitable sharing of benefits arising from the use of biological resources.
- The act establishes Biodiversity Management Committees at the local level to promote conservation and sustainable use of biodiversity. These committees play a crucial role in documenting and conserving local biodiversity.
- The act recognizes and protects the rights of farmers and local communities in conserving, using, and sharing traditional varieties of crops. This recognition of farmers' rights aligns with the broader context of seed conservation and diversity. Also promotes the conservation of ecosystems to maintain biological diversity. Ecosystem conservation is crucial for ensuring the availability of diverse plant species and varieties, which may be relevant to seed certification.

Plant Quarantine Order (2003) (Regulation for Import into India)

Plant Quarantine (Regulation of Import into India) Order, 2003, is an important legal instrument in India that regulates the importation of plants, plant products, and other regulated articles into the country. It is administered by the Plant Quarantine Division of the Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

The order covers a wide range of regulated articles, including plants, plant products, seeds, and other materials that may harbor pests or diseases. The regulation applies to both commercial and non-commercial consignments. Importers are typically required to obtain phytosanitary certificates from the exporting country's plant protection authority. These certificates attest that the consignments meet the phytosanitary standards and have been inspected and found free from quarantine pests. Notified in compliance with the Sanitary and Phytosanitary Agreement of WTO. Pest risk analysis was made a prerequisite for all imports. Gives various schedules for the import of various plants and planting materials.

Plant quarantine measures are essential to protect agriculture and biodiversity by preventing the introduction of harmful pests and diseases. These regulations contribute to maintaining the health and productivity of local plant ecosystems.

PEST RISK ANALYSIS (PRA)

- Pest Risk Analysis is mandatory before any plant or plant materials are permitted to be imported into the country.
- The Import Permit issuing authorities shall issue import permits for commodities specified in PQ Order, 2003 for which PRA has already been done.
- Export inspection and phytosanitary certification of plants and plant products is carried out following the International Plant Protection Convention (IPPC) to meet the legal obligations of the member countries.

Organic Farming Certification

Organic farming certification in India is provided by the National Programme for Organic Production (NPOP) and its regulatory body, the Agricultural and Processed Food Products Export Development Authority (APEDA). Organic products are grown using an environmentally and socially responsible approach, without the use of chemical fertilizers and pesticides. The certification means that farmers and businesses have met strict standards for the growing, processing, and handling of their products.

The National Policy on Organic Farming (NPOF) was enacted in 2005, this policy aims to promote organic farming throughout India by providing support for research, development, and extension activities related to organic agriculture. It also encourages the production and use of organic inputs.

Conclusion

In conclusion, the regulatory landscape governing seed certification and related agricultural activities is multifaceted and involves a comprehensive framework of laws and policies. The national regulatory mechanisms, varying across countries, are shaped by diverse agricultural practices, climates, and specific needs. Key components of these regulatory mechanisms include legislation and regulations. The implementation of these policies is crucial, involving field inspections, seed testing, and proper documentation.

Moreover, the national regulatory mechanism for agriculture involves a range of acts and policies. These acts collectively contribute to a holistic approach to agricultural regulation, covering aspects of plant protection, seed quality, environmental conservation, and the rights of farmers and breeders. In summary, a robust and well-implemented regulatory framework for seed certification is essential for sustainable agriculture, ensuring the availability of high-quality seeds, protecting biodiversity, and fostering a competitive yet fair marketplace. The convergence of economic, quality control and environmental regulations underscores the comprehensive nature of these efforts to create a balanced and resilient agricultural sector.

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NATURAL FARMING FOR SUSTAINABLE AGRICULTURE

Article ID: AG-V04-I04-79

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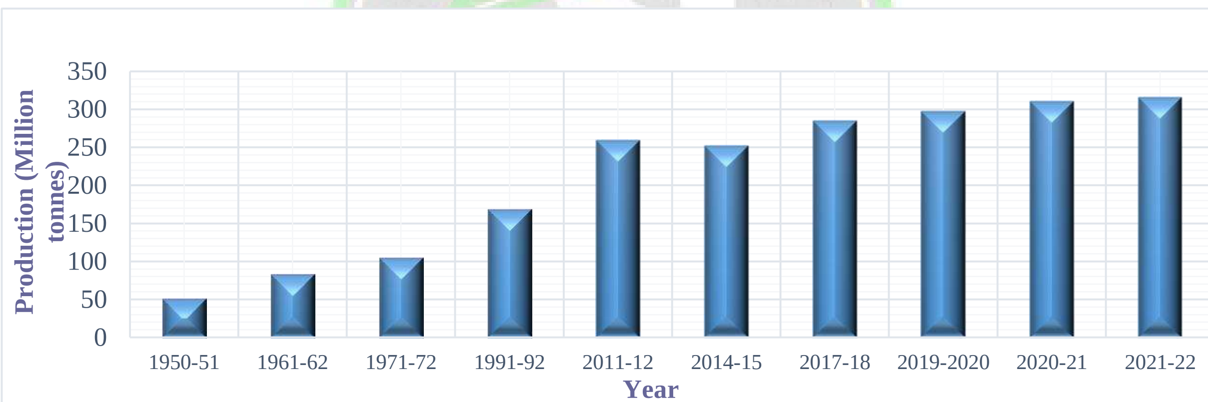
Introduction

- In India, the agriculture sector has been dominated by Green revolution.
- Green revolution has influenced the economy by increasing agricultural production and productivity.
- Spectacular growth in agriculture during last 60 years observed



Source: Ministry of Agriculture and Farmer's Welfare

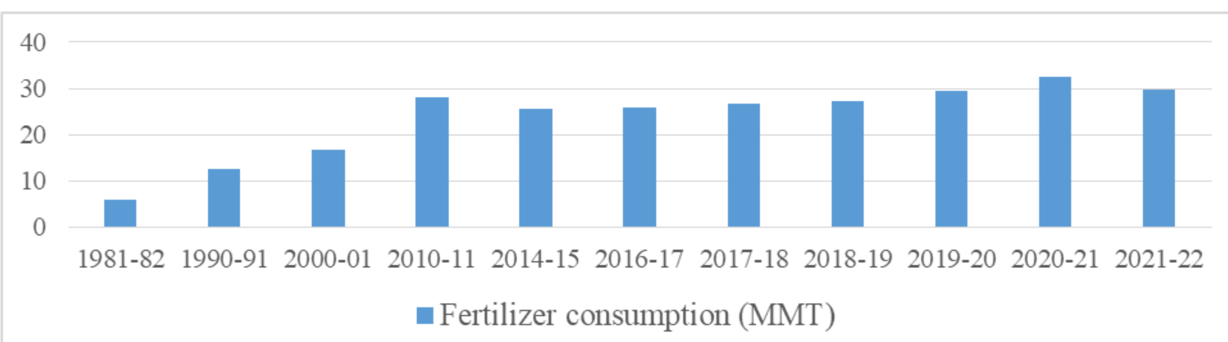


Fig.2: Increased consumption of fertilizer in India

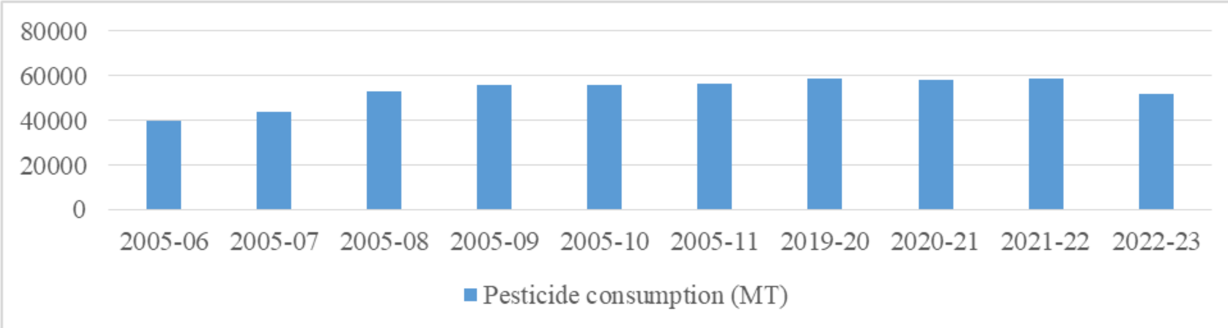


Fig.3: Increased consumption of pesticides in India

Source: Directorate of Plant Protection, Quarantine & Storage

Some adverse effect of green revolution

1. Air pollution
2. Water consumption
3. Impact on soil and crop production
4. Impact on human health
5. Extinction of indigenous variety
6. Impact on farmers

- Many harmful effects of pesticides and chemical fertilizers, despite billions of kg of pesticides and fertilizers are used annually.
- Sustainability in agriculture is one of the major concerns of humanity as today.
- To find farming systems which works in harmony with nature rather against it.

What is Natural farming?

- It is also referred to as "THE FUKUOKA METHOD", "THE NATURAL WAY OF FARMING " or "DO - NOTHING FARMING".
- **Natural farming** may be defined as a farming without chemicals and relies on varied farming system based on agro-ecology, that integrates crops, trees and livestock.
- Natural farming allows the optimum use of functional biodiversity, which encourages the use of on-farm inputs prepared by the farmers and the indigenous breed of cow (desi cow) are preferred and plays a vital role in natural farming system.
- Other cattle’s dung and urine can also be used for preparation of concoctions which builds on natural or ecological processes that exist in or around farms.
- Philosophy of natural farming is working with nature to produce healthy food.

Why Natural farming is important?

- Farmers depend on loans
- Cost of farming inputs is rapidly increasing
- The number of farmer's suicide cases is growing continuously
- The demand for safe food increased among customers
- Deteriorate soil health

Historical perspective

- India blessed with a rich jaivik agricultural wisdom since Rigveda (C. 8000 BCE). vedas mention jaivik agriculture as the main industry of the ancient Bharat.
- The knowledge of regenerative, sustainable and eco-friendly agricultural practices of vrikshayurveda farming, developed by our pioneers of agriculture.
- Vrikshayurveda is the ancient Indian science of plant life, a body of knowledge that has been systematically compiled in the form of 325 Sanskrit *slokas* in a text named vrikshayurveda by Surapala approximately 1000 years ago.
- By adopting these jaivik practices farmers were prosperous and Bharat was known as golden bird and farming was considered the best enterprise followed by business, jobs.

Vrikshayurveda entirely based on:

(i) Minimum disturbance to nature (eco-friendly)

(ii) Harmonious living as a guiding principle

Masanobu Fukuoka (1913-2008) (Author, Philosopher and Farmer)

- Philosophy of working with nature, rather than against nature with minimum interference.
- **Do Nothing Farming** – "How about not doing this and How about not doing that?" – this was the path he followed.
- **Key Principles** – No tillage, No external input, No weeding, Soil mulch and No pruning
- Trying to take the human intellect out of the decision making.

Zero budget natural farming

- Zero budget natural farming, as the name implies, is a farming method where the cost input in growing and harvesting the plants is zero.
- This means farmers do not need to purchase fertilizers and pesticides to ensure the growth of crops
- The word 'zero' means the cost included in this farming will be compensated with the profits

gained.

- Four pillars or components of ZBNF are ***Bijamrut, Jivamrut, Acchadana*** **(Mulching)** and ***Whapsa*** **(Moisture).**

1. *Bijamrut*

Bijamrut, an organic, was used to treat seeds prior to sowing in order to improve germination and protect young roots from fungi, as well as soil-borne and seed-borne diseases. Local cow dung- a powerful natural fungicide, cow urine- a potent anti-bacterial liquid, lime, water, and soil are among the ingredients. Average nutrients content of *bijamrut* was 2.38% N, 0.127% P, 0.485 % K, 282 ppm Fc, 4.29 ppm Zn, 1.58 ppm Cu, 10.7 ppm Mn; and 435 cfu x 10^5 bacteria, 11 cfu x 10^4 fungi and 2 cfu x10^3 actinomycetes count.

Procedure:

- *Bijamrut* was made by wrapping 5 kg of cow dung in a rag, taping it together and hanging it in 20 L of water for 12 hours.
- Dissolve 50 g of lime in 1 L of water and set aside for the night.
- Next, squeeze a bundle of cow dung in that water three times continuously the next morning, until all of the cow dung's essence is collected in that water.
- Pour a pinch of soil into the water solution and thoroughly mix it.
- Finally, stir in 5 L of cow urine and lime water thoroughly.

Application:

Add *bijamrut* to seeds (200-300 ml/kg seed) of any crop, coat them, mixing by hand, dry them and use for sowing. For seedlings, just dip them in *bijamrit* and dry.

2. *Jivamrut*

In the plant system, *Jivamrut*, an organic product, has the ability to promote growth and provide immunity. *Jivamrut* is made up of four different ingredients: cow dung, cow urine, chickpea flour, and jaggery. These have miraculous effects when properly combined and used. Average nutrients content in it was 1.96% N, 0.173% P, 0.280% K, 15.35 ppm Fe, 2.95 ppm Zn, 0.52 ppm Cu, 3.32 ppm Mn and 213 cfu x 10^5 bacteria, 11 cfu x 10^4 fungi and 1 cfu x10^3 actinomycetes count.

Procedure:

- The *jivamrut* was made by combining 10 kg desi cow dung, 10 L cow urine, 2 kg local jaggery, 2 kg pulse flour and a handful of soil from a Banyan tree's rhizosphere.

▪ All of this was combined in a plastic drum with a capacity of 200 L and thoroughly mixed, resulting in a volume of 200 L.

▪ The mixture was stirred well in clock wise direction and kept in shade covered with wet jute bag.

▪ The solution was regularly stirred clockwise in the morning, afternoon and evening for continuously 5-6 days and it was used for soil application.

Application:

- Apply when ground is wet.
- Use at least once every month.
- 500 liter is required for 1 acre.
- Can also be applied along with irrigation water.

3. *Ghan jivamrut*

Ghan jivamrut is dry or solid *jivamrut* that acts as a natural fertilizer for the crop plants. *Ghan jivamrut* was prepared from desi cow dung, cow urine, jaggery and pulse flour.

Procedure:

▪ First, moisten 100 kg of desi cow dung with water.

▪ Next, add 2.5 L cow urine, 2 kg jaggery and 2 kg pulse flour.

▪ Mix well and store as a heap for 48 hours in the shade.

▪ Spread the mixture on a clean surface and dry it after 48 hours.

▪ Turn it upside down throughout the day so that all particles are exposed to sunlight and can quickly dry.

▪ Until fully dry, split the lumps into powder shape with the wooden bat, fill into bags, store in a cool and dry location.

Application- At the sowing period, use the 800 kg *Ghana jivamrut* per acre. For example, two hands of *Ghana jivamrut* with each seed.

Advantages- It helps the soil to activate their available nutrients, microorganisms to make them available for the crop sown in that particular area. It increases the count of earthworms in soil which is beneficial for soil fertility. It have large number of nutrients which will ensure higher yield by enhancing the availability of nutrients through faster decomposition of bulky organic manures by boosting the microbial activity in the soil.

4. *Acchadana* /Mulching

▪ Mulching is the practice of applying a layer of mulch to the top of the soil.

▪ Mulching is a powerful tool for improving crop quality and yield by regulating soil temperature, maintaining moisture and reducing soil evaporation.

5. *Wapsa*

▪ *Wapsa* is a condition where water molecules and air molecules are present in the soil.

▪ It helps to reduce the extra irrigation requirement.

▪ The irrigation should be reduced and practiced only at noon, in alternate furrows.

▪ When roots need water vapor, not much irrigation water.

Other important principles of ZBNF

1. Intercropping –

➢ This is primarily how ZBNF gets its "Zero Budget" name. It doesn't mean that the farmer is going to have no costs at all, but rather that any costs will be compensated for by income from intercrops, making farming a close to zero budget activity.

➢ Palekar explains in detail the crop and tree associations that work well for the south Asian context.

2. Contours and bunds –

➢ To preserve rain water, Palekar explains in detail how to make the contours and bunds, which promote maximum efficacy for different crops.

3. Local species of earthworms -

➢ Palekar opposes the use of vermicompost. He claims that the revival of local deep soil earthworms through increased organic matter is most recommended.

4. Cow dung -

➢ According to Palekar, dung from the *Bos indicus* (humped cow) is most beneficial and has the highest concentrations of micro-organisms as compared to European cow breeds such as Holstein.

➢ The entire ZBNF method is centered on the Indian cow, which historically has been part of Indian rural life.

Plant protection in ZBNF:

1. *Neemastra*
2. *Bramhastra*

3. *Agniastra*
4. *Dashparni ark*

Advantages of zero budget natural farming:

• Zero budget natural farming reduces the initial cost of farmers.

• Farmer's income automatically increases.

• Bacteria of cow dung decompose the organic matter in soil and make soil nutrients available for the plants.

• ZBNF improves productivity of the soil.

• It decreases the disease attack risk on the crop.

• The soil ecosystem improves.

Disadvantages of zero budget natural farming:

• This farming method used in some parts of India.

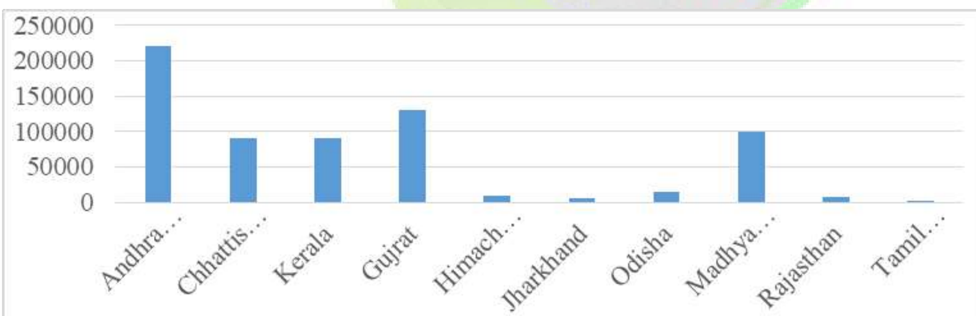
• There is not much scientific research under evaluation.

• It is highly sustainable farming.

Initial works on natural farming in India:

➢ Natural farming in India is still at a nascent stage. To scale it up and make it a mass movement, governments at the centre and in states must take big steps.

➢ Mainstreaming natural farming will address the ecological, economic and existential crisis in Indian agriculture.



Till now 6.5 lakh ha. area is covered under natural farming in India.

Fig.4: Major states in India adopted natural farming

Government schemes promoting natural farming:

• In India, Natural Farming is promoted as Bharatiya Prakritik Krishi Paddhati Programme (BPKP) under centrally sponsored scheme Paramparagat Krishi Vikas Yojana (PKVY).

• BPKP is aimed to promoting traditional indigenous practices which reduces externally purchased inputs.

- It is largely based on on-farm biomass recycling with major stress on biomass mulching, use of on-farm cow dung-urine formulation, periodic soil aeration and exclusion of all synthetic chemical inputs and reduce dependency on purchased inputs and will help to ease smallholder farmers from credits burden.
- The BPKP programme has been adopted in state of Andhra Pradesh, Karnataka, Himachal Pradesh, Gujarat, Uttar Pradesh and Kerala.

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BIOCHAR: A NEGATIVE CARBON EMISSIONS TECHNOLOGY

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Introduction

Since 2000, anthropogenic carbon dioxide (CO2) emissions have risen by more than 3% year, putting Earth's ecosystems in danger of irreversibly changing due to an extremely rapid rate of climate change. A prompt and comprehensive mitigation measures strategy is required to reverse this trend. The production of biochar and its subsequent soil storage have been suggested as viable approaches to reduce atmospheric CO2 levels. The process of pyrolysis converts biomass into a stable carbon form, which creates biochar, a technology that emits no carbon. Because of its great porosity and ability to store carbon in the soil for tens of thousands of years, biochar is a powerful weapon against climate change. In recent years, the production and use of biochar has gained interest as a possible means of reducing atmospheric carbon dioxide concentrations. This can be accomplished both directly and indirectly.

Effect of pyrolysis conditions on biochar carbon sequestration potential

1 The degree of heat

One of the most important factors influencing biochar's ability to sequester carbon during pyrolysis is temperature. larger pyrolysis temperatures often produce biochars with larger carbon contents and greater recalcitrance because they release more volatile compounds and condense and stabilise the residual carbon structure. However, very high temperatures may result in significant carbon loss as gaseous products, which would reduce the amount of carbon that biochar might store.

2 Heat Rate

The rate of heating, or heating speed, of the biomass during pyrolysis can potentially have an impact on how well biochar sequesters carbon. Heating materials quickly might result in the production of biochars with a higher carbon content. On the other hand, excessively fast pyrolysis might result in uneven pyrolysis and less biochar that can sequester carbon.

3 Duration of Residency

Extended periods of residence might facilitate a more thorough pyrolysis process, perhaps yielding biochars with a higher carbon content and improved stability. Longer residence periods, however, may cause more biomass to volatilize and produce biochars with a lesser capacity to store carbon.

4 Selection of Feedstock

The ultimate quantity of carbon trapped in the biochar may vary depending on the carbon content of the feedstocks employed. Biochars with higher carbon sequestration potential are often produced from feedstocks with higher carbon contents, such woody biomass, as opposed to feedstocks with lower carbon contents, like herbaceous or aquatic plants.

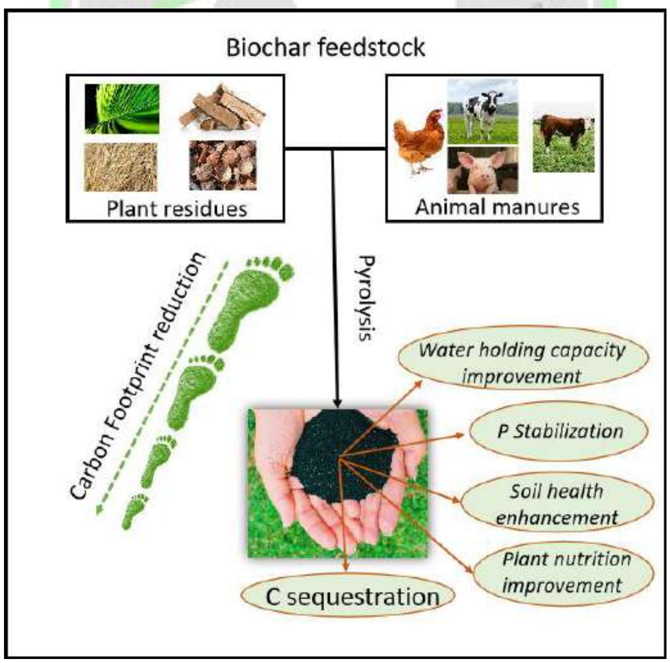

Fig: 1 Biochar for reducing carbon footprints in land-use systems

Carbon sequestration

The process of removing atmospheric CO2 through photosynthesis to create organic matter, which is then eventually deposited in the soil as stable, long-lasting forms of carbon, is known as soil carbon sequestration. The Earth's system's carbon fluxes and pools make up the global carbon cycle. Biochar absorbs carbon dioxide from the atmosphere and stays in the soil for long periods of time because it contains stable carbon. Through this procedure, greenhouse gas emissions are reduced, so mitigating climate change. It has been demonstrated that adding biochar to soil would eventually capture large amounts of carbon (Lehmann & Joseph, 2015). To lower the quantity of carbon in the atmosphere, carbon must be transferred into a passive pool containing stable or inert carbon.

Because of biochar, carbon may flow from the active pool to the passive pool with ease. Even larger volumes of biomass organic matter are converted into stable carbon pools by controlled carbonisation, as opposed to burning, and are expected to persist in the environment for millennia. When biomass carbon is transformed to biochar, almost half of the initial carbon is stored, compared to the negligible amounts that are kept after burning (3%) and biological breakdown (less than 10–20% after 5–10 years) (Lehmann et al., 2006). Carbon sequestration in biochar prolongs the period that carbon is stored in comparison to other terrestrial sequestration techniques like afforestation or re-forestation (Ogawa et al., 2006 and Sohi et al., 2010).

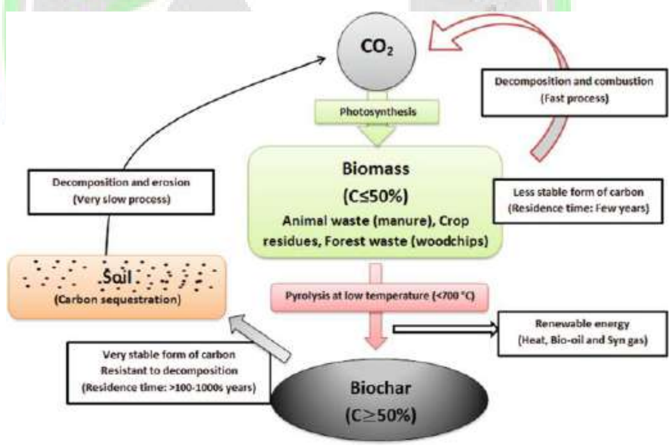

Fig: 2 Process of carbon sequestration by biochar

A 12% reduction in anthropogenic carbon emissions due to land use change may be achieved by transitioning from the slash-and-burn technique to the slash-and-char strategy per year (0.21 Pg C). According to Sololins et al. (1996), the main mechanisms at play in soils that stabilise biochar penetration and greatly lengthen its stay there include the creation of connections between mineral surfaces, intrinsic recalcitrance, and spatial separation of decomposers and substrate. Among the biochars, maize biochar showed the least amount of carbon mineralization, suggesting a greater potential for long-term carbon sequestration. The amount of carbon in the soil under the wheat-pearl millet agricultural system reached its peak when biochar was added. The findings of a recent modelling study (Woolf et al., 2010) indicate that, when added to soil in a responsible manner, biochar additives have the capacity to capture a yearly amount of carbon equal to 12% of the current human CO2 emissions. They estimate that between one to 1.8 giga tonnes (Gt) C year will be the maximum feasible technical capability for biochar-based carbon abatement by 2050. Several hundred billion tonnes of carbon emissions might be sequestered or offset by 2100, according to technical estimations of the ability for biomass pyrolysis combined with soil storage to do so. This is a significant portion of the total required to ameliorate global climate damage.

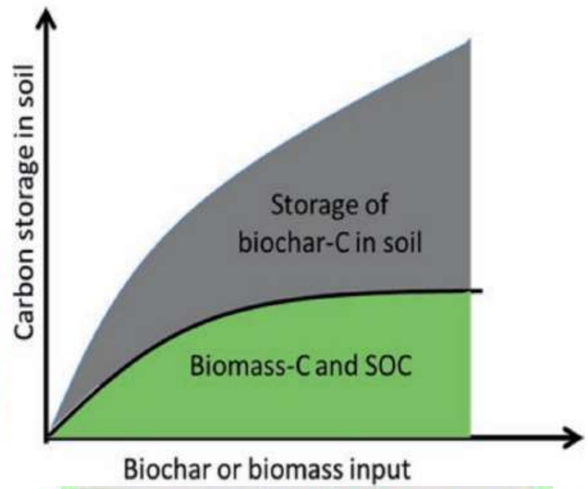

Fig: 3 Soil carbon storage after application of biochar and biomass in to the soil.

Apart from its capacity to store carbon, biochar has demonstrated several other agronomic benefits. Utilising biochar improves soil fertility and quality, enhances nutrient cycling, holds onto more water and nutrients, boosts crop yield, and increases the efficiency of water and nutrient usage (Murtaza et al., 2023). Furthermore, biochar has been credited as being essential in reducing greenhouse gas emissions from soil, including CO_2, CH_4, and N_2, despite contradicting studies on its efficacy (Kamali et al., 2022).

Conclusion

With its numerous co-benefits, biochar has great potential as a negative carbon emission technology. It reduces the generation of CO2 and sequesters carbon in the soil. Policymakers, academics, and stakeholders must work together to overcome the technological, financial, environmental, and social issues that arise in order for it to be widely implemented. One such tactic that has the potential to be a game-changer in reducing the effects of climate change is biochar.

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HEALTH BENEFITS AND NUTRITIONAL CONTENT OF MINOR MILLETS

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Introduction

Minor millets are a group of five crops comprising of proso millet, little millet, barnyard millet, kodo millet and foxtail millet. Millets have nutraceutical properties in the form of antioxidants which prevent deterioration of human health such as lowering blood pressure, risk of heart disease, prevention of cancer and cardiovascular diseases, diabetes, decreasing tumor cases etc. These minor millets are three to five times nutritionally superior to rice and wheat in terms of proteins, minerals and vitamins. Millets are rich in vitamin B, calcium, iron, potassium, magnesium, zinc, also gluten-free and has low Glycemic index, thus millets are suitable for people allergies or intolerance of wheat and diabetic.

Proso millet

Grains are rich in minerals and vitamins, and their nutritional parameters are only slightly different from those of common cereals. After drying, the protein quality decreases, but the protein content increases. Proso millet consists of protein and niacin (Vitamin B3). Traditionally, it's used as a recuperative food, particularly after pregnancy and illness.

Little millet

Little millet is rich in cholesterol, when consumed increases good cholesterol in the body, suitable for growing kids and strengthens the body. Its complex carbohydrate digests slowly which is very helpful for diabetic patients. It contains high levels of phosphorous 220 mg 100 g^{-1} and iron 9.3 mg 100 g^{-1}. It's especially good for people with low body mass.

Barnyard millet

It's a good source of protein which is very easy to digest, and it's an excellent source of dietary fiber with good concentrations of soluble and insoluble fractions. The barnyard millet is low in carbohydrates and slowly digestible, which makes it a natural gift to modern people who are engaged in sedentary activities. Barnyard millet is most effective in reducing blood glucose and lipid levels. It contains high amounts of dietary fiber that help improve bowel movements and support weight loss. It is rich in calcium and phosphorus, which can strengthen bone density.

MILLETS NUTRITION FACTS PER 100 GRAMS

Minor Millet	Protein (g)	Fat (g)	Fiber (g)	Minerals (g)	Iron (mg)	Calcium (mg)	Phosphorus (mg)	Calories (kcal)
Proso millet	**12.5**	1.1	14.2	1.9	0.8	14	206	356
Little millet	8.7	5.3	12.0	1.5	**9.3**	17	220	207
Barnyard millet	11.6	**5.8**	13.5	**4.4**	5.0	20	280	342
Kodo millet	8.3	1.4	**15.0**	2.6	0.5	27	188	309
Foxtail millet	12.3	4.3	14.0	3.3	2.8	**31**	**290**	**473**

Kodo millet

Kodo millet is traditional food which helps to use in weight loss. It is easily digestible and is rich in phytochemicals and antioxidants which help in preventing different lifestyle related diseases. It's helping to reduce pain in joints and knees, while also making the menstrual cycle regular for women. It has a significant effect on strengthening the nervous system. It can relieve cardiovascular disorders such as high blood pressure and cholesterol levels when eaten regularly by postmenopausal women.

Foxtail millet

Foxtail millet is good source of beta – carotene, which is the precursor of Vitamin A. Foxtail millet helps to maintain a steady glucose release without affecting the metabolism of the body. Foxtail millet has been shown to reduce the incidence of diabetes and is also known as a healthy food for your heart, thanks to its good magnesium content. Foxtail Millet can improve overall human's immunity.

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ENHANCING EVAPOTRANSPIRATION MODELLING THROUGH SUPPORT VECTOR MACHINE (SVM)

Article ID: AG-VO4-I04-82

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Abstract

Evapotranspiration (ET) is vital for hydrology, agriculture, and ecology, necessitating accurate estimation for effective water resource management. Support Vector Regression (SVR) have gained traction for ET modelling due to their ability to handle complex relationships. This article discusses SVM-based ET modelling, applications, strengths, and limitations. SVR's efficacy lies in finding optimal hyperplanes in high-dimensional spaces, making it suitable for capturing intricate ET relationships. Applications across diverse environments demonstrate SVR's superiority over traditional methods, enhancing ET estimation accuracy. However, challenges like parameter selection and computational complexity exist, requiring careful consideration. Recent advancements include integrating remote sensing and hybrid modelling, improving SVR's performance and applicability. Future research may focus on refining hybrid models and addressing interpretability and uncertainty concerns. SVM-based ET modelling can present a promising avenue for advancing water management and ecological studies. By addressing challenges and leveraging recent innovations, SVR can contributes to accurate ET estimations.

Keywords: Evapotranpiration (ET), Support vector regression (SVR), modelling, application

Introduction

Evapotranspiration (ET) represents the combined processes of water vapor transfer from the Earth's surface to the atmosphere through evaporation from soil and water bodies and transpiration from vegetation (Allen *et. al.*,1998). It plays a pivotal role in the water cycle, energy balance, and climate system. Accurate estimation of ET is essential for various applications, including hydrological modeling, agricultural water management, drought assessment, and ecosystem studies. Support Vector Machine (SVM) is a supervised machine learning algorithm that has shown promise in various fields, including hydrology and water resources. SVM aims to find the optimal hyperplane that maximizes the margin between different classes or regression targets in a high-dimensional feature space. It is particularly effective in handling nonlinear relationships and high-dimensional datasets (Vapnik, 1995).

SVM-Based ET Modelling Approaches

Traditional methods for estimating ET include empirical equations, energy balance methods, and numerical models such as the Penman-Monteith equation and the Priestley-Taylor equation. While these methods are widely used, they often require extensive input data, assumptions, and parameterization, leading to uncertainties in ET estimation, especially in data-scarce regions or complex landscapes. Support Vector Machine (SVM) techniques have been increasingly utilized for evapotranspiration (ET) modelling across diverse geographical regions and ecosystems. One notable study by Zhang *et al*. (2018) applied SVM to estimate ET in the Heihe River Basin, China. Their research demonstrated the effectiveness of SVM in capturing the spatial and temporal variability of ET within this complex hydrological system. By leveraging SVM's ability to handle nonlinear relationships and high-dimensional datasets, Zhang et al. provided valuable insights into ET dynamics in the basin, contributing to improved water resource management strategies in the region. In a similar vein, Smith *et al*. (2020) employed SVM for ET estimation in agricultural areas, showcasing its superiority over traditional empirical equations. Their study highlighted the enhanced accuracy of SVM-based models in capturing the intricate interactions between meteorological variables, land surface characteristics, and ET rates in agricultural settings. By leveraging SVM's flexibility and robustness, Smith et al. provided farmers and water managers with more reliable ET estimates, facilitating better irrigation scheduling and water resource allocation decisions. Furthermore, a more recent study by Li *et al*. (2022) further underscores the utility of SVM in ET modelling. In their research, Li et al. applied SVM techniques to estimate ET in semi-arid regions of Australia. Through comprehensive analysis and validation, they demonstrated the capability of SVM models to accurately capture ET dynamics in water-limited environments, aiding in sustainable water management practices and ecosystem conservation efforts. Li et al.'s findings further validate the effectiveness of SVM-based approaches in diverse hydrological contexts, reinforcing the importance of incorporating machine learning techniques into ET modelling frameworks for improved accuracy and reliability. Overall, these studies collectively emphasize the growing significance of SVM in advancing ET modelling research and its practical applications in water resource management and agricultural practices.

Steps of SVR for ET estimation

Following steps should be considered for modelling the ET through SVR

1. Data quality Dataset: It's crucial to start with a high-quality dataset containing relevant meteorological and environmental variables such as temperature, humidity, wind speed, solar radiation, and soil moisture.
2. Feature Selection: Identifying the most relevant features (independent variables) that influence ET is essential. This typically includes temperature, humidity, solar radiation, and other pertinent factors.
3. Preprocessing: Before inputting the data into the SVR model, preprocessing steps may be necessary. This could involve handling missing values, normalizing or standardizing features, and possibly scaling features to ensure equal contribution.
4. Kernel Selection: SVR uses various kernel functions (e.g., linear, polynomial, radial basis function) to transform the input space into a higher-dimensional space. The choice of kernel function can significantly affect model performance (Tikhamarine *et. al*., 2020).
5. Hyperparameter Tuning: SVR has hyperparameters that need optimization for the best model performance. These include the regularization parameter (C), kernel-specific parameters (e.g., gamma for RBF kernel), and the epsilon parameter (ε) which controls the margin of tolerance.
6. Model Evaluation: Proper evaluation of the SVR model is essential to assess its performance accurately. Common regression metrics include mean absolute error (MAE), mean squared error (MSE), root mean squared error (RMSE), and coefficient of determination (R^2).
7. Cross-Validation: Cross-validation techniques, like k-fold cross-validation, should be employed to ensure model robustness and prevent overfitting.
8. Model Interpretation: Understanding the SVR model's predictions and its relationship with input features is crucial for interpreting ET estimates. Techniques such as feature importance analysis and partial dependence plots can aid in model interpretation.

9. Monitoring and Updating: After deploying the SVR model, monitoring its performance over time is vital. Changes in environmental conditions or land use may necessitate retraining the model with new data.

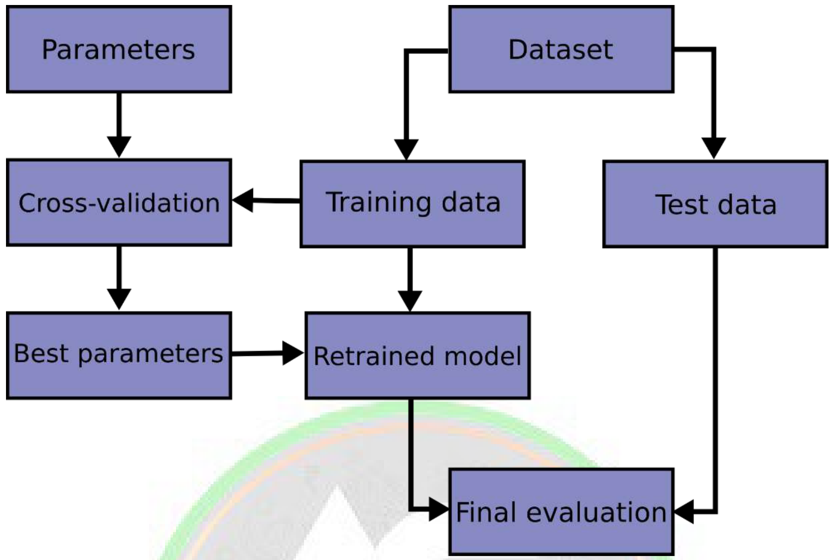

Figure: Steps of SVR modelling

Challenges in SVR modelling for ET

Identifying the most influential features for ET estimation poses a significant challenge. Inadequate consideration of relevant variables or improper feature selection methods can lead to suboptimal SVR models. SVR model performance is highly sensitive to the quality of input data. Issues such as missing values, outliers, and measurement errors can significantly impact the reliability of the model's predictions. SVR models are susceptible to overfitting, particularly when dealing with small or noisy datasets. Without appropriate regularization techniques or hyperparameter tuning, SVR may capture noise in the training data, resulting in poor generalization to unseen data. SVR models are often perceived as "black-box" models, making it difficult to interpret the underlying relationships between input features and ET estimation. Enhancing model interpretability while maintaining predictive performance is an ongoing challenge.

Advantages of SVR modelling for ET

Despite of challenges SVR offers several advantages for ET estimation, overcoming its shortcomings. SVR excels in capturing complex, nonlinear relationships between input variables and evapotranspiration (ET). This ability allows SVR to model intricate dependencies in the data, providing more accurate ET estimates compared to linear regression approaches. SVR demonstrates resilience against outliers and noise present in the dataset, by focusing on support vectors, SVR effectively filters out irrelevant data points, leading to more robust ET estimates. SVR offers the flexibility to utilize various kernel functions, including linear, polynomial, and radial basis function (RBF). This adaptability enables SVR to capture diverse patterns and relationships in the data, enhancing its predictive performance of ET. it also performs well in high-dimensional feature spaces, making it suitable for ET estimation tasks with numerous input variables. It effectively handles the multidimensional nature of meteorological and environmental factors influencing ET, resulting in more accurate predictions. Since it incorporates regularization techniques thus it prevents overfitting and improves the generalization. By controlling the model's complexity, regularization ensures that SVR performs well on unseen data, enhancing its reliability for ET estimation. SVR also focuses on minimizing structural risk, leading to superior generalization performance. The optimization process aims to maximize the margin between support vectors, resulting in a model less susceptible to overfitting and better able to generalize to new ET which is mostlr the predictive ET. Also, SVR can yield reliable ET estimates even with limited data, making it suitable for scenarios with small datasets. By emphasizing the most informative data points, SVR can produce accurate ET estimates despite data scarcity.

Conclusion

Support Vector Regression (SVR) stands out as a robust approach for modelling ET. Its capacity to handle high-dimensional data and nonlinear relationships can proves to be invaluable in capturing the intricate patterns inherent in ET dynamics. Through meticulous optimization of kernel functions and parameter tuning, SVR demonstrates the ability to generalize from training data, yielding accurate predictions for ET variables. Its versatility allows for adaptation to diverse ET modelling. Overall, SVR emerges as a valuable tool in the realm of ET modelling, offering insights crucial for understanding and managing environmental systems.

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ORGANIC FARMING AND ITS NUTRIENT MANAGEMENT

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Abstract

Organic farming is a production system which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and live stock feed additives. In Green revolution technology such as greater use of synthetic agro chemicals like fertilizers and pesticides, adoption of nutrient responsive, high-yielding varieties of crops, greater exploitation of irrigation potentials etc. has boosted the production output in most of cases. Without proper use of these high energy inputs is leading to decline in production and productivity of various crops as well as deterioration of soil health and environments. Due to Green revolution there is change in soil reaction, imbalance of nutrients, reduce the earth worm activity, reduce soil flora and fauna, reduction in organic matter, reduction in productivity, destruction of soil structure, aeration and water holding capacity and change in atmospheric composition,. All these problems of Green revolution technology lead to not only reduction in productivity but also deterioration of soil health as well as natural eco-system. Moreover, today the rural economy is now facing a challenge of over dependence on synthetic inputs and day by day it change in price of these inputs. Agriculture gave birth to various new concepts of farming such as natural farming, organic farming, bio-dynamic agriculture etc.To maintain soil health and healthy ecosystem, there is need for adoption of an alternatives farming system like organic farming and Natural farming.

Key Words : Organic farming, Natural farming, Nutrient Management,

Introduction

Organic farming is a method of agricultural production that excludes the use of synthetic substances, such as pesticides and fertilizers. According to national organic standards board of the U.S. defines organic farming as an ecological production management system that promotes and enhances bio diversity, biological cycles and soil biological activity. Organic farming refers to organically grown crops which are not exposed to any chemicals right from the stage of seed treatments to the final post harvest handling and processing. Organic farming relies on crop rotation, crop residues, animal manures, legumes, green manures, off-farming organic wastes, agricultural cultivation, mineral bearing rocks and aspect of biological pest control to maintain soil productivity and tilth to supply plant nutrients and also to control insects, weeds and other pests. In India Organic farming and Natural farming gaining popularity due to its health benefits and environment stability.

Organic farming practices that reduces the pressure on land, water and bio-diversity without adverse effects on agricultural production and nutritive value of food comprise, judicious use of organic manure, viz. farm yard manure, compost, crop resides, Vermicompost etc. integrated is an efficient nutrient management practices, cropping systems, conjunctive use of rain, tank and under ground water, integrated pest management and conservation of genetic resources. Among them, soil fertility is give top attention due to its dynamic action with various physical, chemical and biological properties. Besides this, following advantages derived from organic farming. The agriculture today in the country is hampered by erosion of natural resources viz., land, water, biodiversity, fast declining soil fertility and use efficiency of inputs, such as water, fertilizer and energy.

The present day for self sufficiency in food grain production may not last longer unless we develop a sustainable agricultural system which maintains and /or improves soil fertility and productivity with greater acceptance of biological principles so as to assure adequate/more food production in future. Besides plants are more prone to pest and diseases in intensive agriculture, use of chemicals can have residues on the produce, in the soil and in ground water. With more of purchased inputs cost of production is also mounting up. Pesticides use in paddy, cotton and vegetables which occupy less than 30 per cent of total area account for more than 80 per cent of the chemicals used.

Advantages of Organic farming and Natural farming

- Organic farming and Natural farming produce optimal conditions in the soil for high yields and good quality crops.
- They supply all the nutrients required by the plant (Primariy, secondary and micronutrients).
- They improve plant growth and physiological activities of plants.
- They improve the soil physical properties such as granulation and tilth, giving good aeration, easy root penetration and improved water holding capacity. The fibrous portion of the organic matter with its high carbon content promotes soil aggregation to improve the permeability and aeration of clay soils while its ability to absorb moisture helps in the granulation of sandy soils and improves their water holding capacity. The carbon in the organic matter is the source of energy for microbes which helps in aggregation.
- They improve the soil chemical properties such as supply and retention of soil nutrients and promote favourable chemical reactions.
- They reduce the need for purchased inputs.

Disadvantages of organic farming and Natural farming

- Organic farming takes four years for a farmer to free his land completely stopping the use of chemical as nutrients & crop savers.
- The neighbouring farmers do not well co-operate regarding use of fertilizer, pesticides, weedicides etc.
- Decrease in production of high yielding crops like rice, wheat which needs high fertility status to get potential yield.
- The competitive uses of organic materials such as dung-cakes for domestic cook fuel in villages and bagasse as fuel in sugar factories & villages.
- Wheat & rice straws are disposed by burning, instead of return to the soil.
- Dung, slurry & pig manure and other waste used directly in the field (without compositing), which damage the crop & pollute the ground water.
- Most of organic material is bulky in nature, hence very difficult to store, carry and use.
- Sewage, sludge contains pathogens and, some of them survive more than six months, which may hazard the human life and prove fatal for the animal.

- City garbage contains un-decomposed materials such as metal, plastic, glass, stones, needles etc. which causes many problems,
- Bio control agents are available only for few selected insect pests.
- Complicated organic certification process and also high cost of certification.
- High price expectations, delayed delivery, quality restrictions, lack of certification & marketing net work are the major problems for organic producers.
- Major Indian and multinational companies are not interested in bio pesticides, also dealer's interest in chemical pesticides.

Concept of organic farming

The basic concepts behind organic farming are:

1. It concentrates on building up the biological fertility of the soil so that the crops take the nutrients they need from steady turnover within the soil nutrients produced in this way and are released in harmony with the need of the plants.

2. Control of pests, diseases and weeds is achieved largely by the development of an ecological balance within the system and by the use of bio-pesticides and various cultural techniques such as crop rotation, mixed cropping and cultivation.

3. Organic farmers recycle all wastes and manures within a farm, but the export of the products from the farm results in a steady drain of nutrients.

4. Enhancement of the environment in such a way that wild life flourishes.

In a situation where conservation of energy and resources is considered to be important community or country would make every effort to recycles to all urban and industrial wastes back to agriculture and thus the system would be requiring only a small inputs of new resources to "Top Up" soil fertility.

Characteristics of Organic Farming

The most important characteristics are as follows**:**

1. Maximal but sustainable use of local resources.
2. Minimal use of purchased inputs, only as complementary to local resources.
3. Ensuring the basic biological functions of soil-water-nutrients-human continuum.
4. Maintaining a diversity of plant and animal species as a basis for ecological balance and economic stability.

5. Creating an attractive overall landscape which given satisfaction to the local people.

6. Increasing crop and animal intensity in the form of polycultures, agroforestry systems, integrated crop/livestock systems etc to minimize risks.

Objectives of Organic Farming

1. To produce food of high nutritional quality in sufficient quantity.
2. To work with natural systems rather than seeking to dominate them.
3. To encourage and enhance the biological cycles within farming system involving microorganisms, soil flora and fauna, plants and animals.
4. To maintain and increase the long term fertility of soils.
5. To use, as far as possible, renewable resources in locally organized agricultural systems.
6. To work as much as possible, within a closed system with regard to organic matter and nutrient elements.
7. To given all livestock, conditions of life that allow them to perform all aspects of their innate behavior.
8. To avoid all forms of pollution that result from agricultural techniques.
9. To maintain the genetic diversity of the agricultural system and its surroundings, including the protection of plant and wildlife habitats.
10. To allow agricultural producers for adequate return and satisfaction from their work including a safe working environment.
11. To consider the wider, social and ecological impact of the farming system.

Nutrient management in organic farming

The basic concept of organic farming is the continuous improvement of soil productivity on long-term basis through appropriate use of organic manures, green manures, BGA, biofertilizers and other biological derived materials and their scientific management for optimum growth, yield and quality of crops and intensive cropping systems in specific agro-ecological situations.

Organic manures

Term 'manure' was used originally for denoting materials like cattle manure and other bulky natural substances that were applied to land, with the object of increasing the production of crops. Therefore, manures are defined as the plant and animal wastes which are used as sources of plant nutrients.

Urine is normally low in phosphorus and high in potash, where as about equal parts of nitrogen may be excreted in faeces and urine of the cattle. Hence the manure in which the proportion of the urine was allowed to drain away would be relatively low in N and K. Poultry manure is very important for organic farming due to there will be no loss of urine, since both liquid & solid portions are excreted together.

Fresh poultry manure creates local alkalinity, it may hamper the standing crop. Therefore, it is recommended to preserve the excreta at least for six months with suitable amendments and appropriate microbes.

Advantages of Manuring

- Manures supply plant nutrients including micro nutrients
- They improve soil physical properties
- Increase nutrient availability
- Provide food for soil micro organisms
- Provide buffering action in soil reaction
- Improve soil tilth, aeration and WHC of the soil
- On the basis of concentration of nutrients, manures can be grouped into two categories-

(A) Bulky organic manures

Contain small percentage of nutrients and they applied in large quantities like FYM, compost, green manure, biogas slurry, night soil, sewage and sludge, poultry manure, sheep & goat manure, animal waste, crop residue etc.

Farm Yard Manure (FYM)

Most commonly used organic manure in India. It refers to the decomposed mixture of dung and urine of farm animals along with litter and left over materials from roughages or fodder fed to the animals. It contains 0.5% N, 0.2% P2O5 and 0.5% K2O. Urine contains 1% N and 1.35% K2O. *Litter is the straw, peat, sawdust and dry leaves used as bedding material for farm animals and birds.* The N present in urine is mostly in the form of urea which is subjected to volatilization losses. Chemical preservatives are used to reduce losses and enrich FYM e.g. gypsum, kainite and super phosphate. These preservatives absorb urine and prevent volatilization loss of urea and also add nutrients.

Compost

Composting is the process of reducing animal and vegetable refuse (except dung) to a quickly utilizable condition for improving and maintaining soil fertility. The final well decomposed manure having lower C: N ratio is termed as 'compost'. The recycling of organic materials by biological decomposition as manure is very important for organic farming as it kills weed seeds, pathogenic organisms, and dispose off agricultural / industrial wastes to produce a uniform, slow release organic fertilizer which stimulates soils life, improve soil structure and control insect-pests and diseases. Compost contains 0.5-0.15-0.5 N, P,K, respectively.

Biogas slurry

Instead of directly using the animal dung for composting it can be used for production of biogas by feeding through Biogas Plants. It contains (1–1.8% N, 0.4–0.9% P_2O_5 and 0.6-1% K_2O) due to low volatilization losses of ammonia.

Night soil

Night soil is human excreta, both solid and liquid. It contains 5.5% N, 4% P_2O_5 and 2% K_2O. The dehydration of night soil, as such or after admixture with absorbing materials like soil, ash, charcoal and sawdust produces a poudrette that can be used easily as manure. Poudrette contains about 1.32% N, 2.8% P_2O_5 and 4.1% K_2O.

Sewage and Sludge

The solid portion in the sewage (human excreta + water) is called *sludge* and liquid portion is *sewage water*. It can be recycled for crop fertilization, irrigation to the crop, aquaculture production, application to forest land, biogas production and land reclamation. It was estimated that total waste generated by 217 million people in urban areas is 39 mt/ year (2001). The total NPK content of this would be 2.5 lac tone of N, 2.6 lac tone of P and 2.6 lac tone of K. Both the components are separated and are given a preliminary fermentation and oxidation treatments to reduce bacterial contamination and offensive smell, otherwise soil quickly becomes "**sewage sick**" owing to the mechanical clogging by colloidal matter in the sewage and the development of anaerobic organisms which not only reduce the nitrate already present in the soil but also produce alkalinity. These defects can be removed by thoroughly aerating the sewage in the settling tank by blowing air through it. The sludge that settles at the bottom in this process is called "**activated sludge**" (3.6% N, 2% P_2O_5 & 1% K_2O).

The droppings of sheep and goat contain higher nutrients than FYM and compost. On an average, the manure contains 3% N, 1% P2O5 & 2%K2O). It is applied to the field in two ways- i) Sweeping of sheep and goat sheds are placed in pits for decomposition and it is applied later to the field. ii) Sheep penning- wherein sheep and goats are allowed to stay overnight in the field and urine and faecal matter is added to soil.

Poultry Manure

Poultry manure can supply higher N and P to the soil than other bulky organic manures. The average nutrient content is 2.87% N, 2.93% P2O5 & 2.35% K2O.

Green Manuring

Green un-decomposed plant material used as manure is called green manure. By growing green manure crops (usually leguminous crops) are grown in the field and incorporating it in its green stage in the same field is called green manuring. It adds organic matter and nitrogen to the soil. On an average green manuring gives 60-80 kg N/ha.

Concentrated organic manures

These have required in small quantities and contain higher nutrients as compared to bulky organic manures. The most commonly used are oil cakes, fish meal, meat meal, blood meal, horn & hoof meal, bird guano, raw bone meal etc. which act a good source of organic manures for organic farming system.

Oil cakes

Oil cakes are generally grouped into two groups, viz., *edible* oil cakes suitable for feeding the cattle and other domestic animals and *non-edible* oil cakes exclusively used as manure due to their higher content of plant nutrients. It has been estimated that India produced about 2.5 million tones of oil cakes annually

Non-edible oil cakes are used as manure especially for horticultural crops. Nutrient present in oil cakes, after mineralization, are made available to crops 7-10 days after application. Oil seed cakes need to be well powdered before application for even distribution and quicker decomposition.

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INDIA'S HEAT WAVE: APPROACHING THE LIMIT OF HUMAN SURVIVABILITY

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Introduction

According to the World Meteorological Organization's definition, a heat wave occurs when the daily maximum temperature rises by more than five degrees Celsius over the average maximum temperature for five days. Heat waves are natural occurrences that typically persist for a week or more. Anti-cyclonic flow in the middle and upper troposphere that extends into the lower troposphere is linked to the development of heat waves. As a result, there is significant subsidence, clear sky, warm air advection, and extended surface heat.

IMD criteria for heat wave

The heat wave matrices comprise a minimum of one temperature, either the average, minimum, or maximum temperature. The India Meteorological Department (IMD) defines heat waves based only on maximum temperatures. They define a heat wave as "if the maximum temperature of a station reaches at least 40°C or more for plains, 37°C or more for coastal areas and at least 30°C or more for hilly region".

IMD declares heat wave based on the following criteria

1. When the normal maximum temperature of the location is 40°C or less
    - Normal: - 1°C to 1°C changes from normal temperature
    - Above normal: 2°C rise from normal temperature
    - Appreciably above normal: 3 to 4°C rise from normal temperature

- Markedly above normal or moderate heat wave: 5 to 6ºC rise from normal temperature.
- Severe heat wave: More than 7ºC increase from the normal temperature

2. When the normal maximum temperature of the location is more than 40ºC
   - Normal: - 1ºC to +1ºC
   - Above normal: 2ºC increase from normal temperature
   - Heat wave: 3 to 4ºC increase from normal temperature
   - Severe heat wave: More than 5ºC rise from normal temperature.
3. When the normal maximum temperature of the location is 45ºC or more for two or more days, heat wave is declared.

When the above-mentioned conditions are satisfied for at least two days in a row at two or more meteorological sub-division stations, IMD declares a heat wave.

Heat wave occurrence in India

Heat waves in India often occur in the pre-monsoon months from March to June. Heat waves are common in two regions of India: 1. Central and Northwestern India (heat wave zone); and 2. The East Coast of India (Andhra Pradesh and Odisha). In the first case, heat waves occur more frequently than in the latter. El Nino years bring hotter, longer-lasting heat waves than in normal years.

Heat wave regions often get two heat waves in a season that last five to seven days each. Global warming is blamed for the rising frequency, duration, and maximum temperature of heat waves. Over the past 30 years, the average length of a heat wave in India's heat wave regions has increased by almost three days. The Intergovernmental Panel on Climate Change (IPCC) predicts that by 2060, there will be roughly two more heat waves and a 12- to 18-day increase in heat wave duration. Additionally, heat waves might make their way to Southern India, where none have been detected as of yet.

India had the hottest decade on record from 2014 to 2023, with 425 parts per million of carbon dioxide in the atmosphere, the highest in record. The first and second warmest years on record in India since 1901 were, 2016 and 2023, respectively. In the last 14 years, five of the warmest years in Indian weather history have been documented. In India, the warmest years on record are 2016, 2023, 2009, 2017, and 2010, listed in decreasing order.

Causes and Impacts

Global warming, or the long-term rise in Earth's average temperature brought on by human activities including deforestation, industrialization, and the combustion of fossil fuels, is the main cause of heat waves in India. The frequency and length of heat waves in India are influenced by global variables such as the El Nino Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD). El Nino years and the years that follow typically see an increased frequency of heat waves over the heat wave zone.

El Nino is a natural occurrence that occurs every two to seven years on average. It is characterized by repeated warming of the ocean in the central and eastern tropical Pacific Ocean, lasting nine to twelve months. El Nino not only raises global temperatures but also intensifies rainfall and increases the risk of flooding in some regions of Asia and America, as well as causing tropical cyclones in the Pacific.

The June 2023 El Nino event peaked in November 2023 and persisted into January 2024. Since June 2023, a monthly temperature record has been reached every month. India's temperatures are expected to rise significantly since El Nino conditions are still present in the equatorial Pacific Ocean and are expected to remain and diminish from April to June of 2024.

Heat waves can put a strain on health and agriculture, as well as increase demand for energy, water, and transportation. Security of food and livelihood could also be jeopardized if people lose their cattle or crops to excessive heat. Heat waves also cause fatalities in people.

Conclusion

Heat waves and droughts are anticipated to occur more frequently if global warming is left unchecked. It is time to take steps to lessen the adverse effects of climate change and global warming. Global warming can be slowed down with the use of resilience strategies like sequestering carbon and lowering the release of gases that trap heat in the atmosphere. There is still a long way to go until climate sustainability is achieved.

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WOMEN FRIENDLY TOOL FOR DRY SEEDING OF RICE

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Abstract

Rainfed paddy cultivation faces the problem of low productivity and higher risk. The technologies supports for cost reduction, supports for higher production with limited water availability are needed. The method of establishment plays a crucial role in higher germination, supports for maintain optimum population and leads to higher yield and yield parameters and results in higher productivity and profitability through reduction in cost of cultivation and higher net income by high yield. Several tools are available, the tool suits to the small and marginal farmers and also easily executed by the women folk helps in better employment and completion of sowing in time and helps in higher production. Modified dry drum seeder with accessories for covering seeds with less weight resulted in higher benefit on cost saving by savings of seeds and cost on machine sowing and provides employment opportunity.

Key words: Rainfed, Dry seeding, Modified dry drum seeder, women empowerment

Introduction

Rice serves as a crucial staple food crop, cultivated across a wide array of climatic and agroecological settings globally. A significant portion of the world's population, particularly in Asia, relies on rice as their primary dietary staple. In terms of both acreage and output, India holds a prominent position in rice cultivation, with the largest land area dedicated to rice farming, encompassing approximately 27.1% of the global rice cultivation area. Within South

Asia, rice cultivation spans across 60 million hectares, yielding over 225 million tons of paddy, constituting approximately 37.5% of area and 32% of production of the global cultivation respectively (Singh *et al.* 2013). The cultivation of rice occurs within various agro-ecosystems, with around 52% of the 44.6 million hectares of rice-growing land being rainfed. Consequently, the average yield of rainfed rice ranges between 1.0 to 1.8 tons per hectare, while irrigated rice achieves an average yield of 2.8 tons per hectare. Such disparities in yield underscore the considerable variation in rice productivity across different ecological contexts.

Rainfed Rice

Rice stands out as a primary crop cultivated and consumed in rainfed regions, contributing approximately 25% to global rice production. Being reliant on climatic conditions, rainfed rice farming faces susceptibility to fluctuations in temperature and rainfall patterns. In India, rainfed rice cultivation sustains the livelihoods of millions of the nation's poorest individuals. Despite significant advancements in modern rice technologies benefiting irrigated rice farmers, rainfed rice growers have experienced limited improvements.

In India, rainfed paddy cultivation constitutes 30% of total rice production and provides vital sustenance for some of the nation's most impoverished farmers. This practice predominantly occurs in regions characterized by high annual precipitation, serving as a kharif crop requiring temperatures above 25 degrees Celsius and annual rainfall exceeding 100 cm. In Tamil Nadu, such cultivation is referred to as 'rainfed rice', assuming that soil moisture remains unsaturated throughout establishment and growth periods, given the tropical climate.

The establishment, growth, and maturation of the crop hinge upon received rainfall, leading to standing water from initial establishment to grain filling stages, contingent upon rainfall patterns. In Tamil Nadu, this cultivation method is termed 'rainfed rice', predicated on the assumption of soil moisture remaining unsaturated during establishment and growth phases, within the context of a tropical climate.

STATUS OF SMALL AND MARGINAL FARMERS AND WOMEN FARMERS

Small and marginal farmers, constituting 86.2% of all farmers in India with land holdings of less than two hectares, only possess 47.3% of the total crop area. Conversely, semi-medium and medium landholding farmers, comprising 13.2% of all farmers with land holdings ranging from 2 to 10 hectares, own 43.6% of the crop area. Approximately 57.8% of rural households in India are engaged in agriculture, with over 69% working on marginal landholdings and 17.1% on small landholdings. The substantial number of small and marginal farmers, estimated at close to 126 million according to surveys, presents a challenge for government extension services to effectively disseminate new agricultural technologies to them. Nearly 80% of women in rural India are engaged in and reliant on agricultural development. Women play significant roles in agriculture, constituting 33% of the agricultural labor force and 48% of self-employed farmers in India. Rural women exhibit a higher participation rate in agriculture compared to their urban counterparts, standing at 30.5% versus 20.2%. They contribute around 18% to India's GDP, with nearly 80% of rural women actively contributing to agricultural development efforts.

Establishment Methods in Rice

Rice establishment is practiced by using three important methods of transplanting, dry Direct-Seeded Rice (DSR) under dry and wet. Method of seeding requires differ approaches from one another in terms of land preparation (tillage), crop establishment method, or both. Given the increasingly low water situation in agriculture and the inefficiency of traditional transplanting systems, there is a need for changing the establishment technologies which supports for less water and are high water efficiency. DSR, being a water-wise technology, presents a solution.(Kaur and Singh. 2017) Both dry and wet DSR methods are more water-efficient and offer advantages over transplanting methods. However, with the growing water scarcity, dry DSR plays a significant role in enhancing benefits by saving labor. DSR reduces labor requirements by eliminating nursery raising, seedling uprooting, transplanting, and puddling. Direct-seeded rice (DSR), is the traditional method of crop establishment and gaining popularity by the character of low-input needs.

One of the primary reasons for farmers' interest in DSR is the rising cost of cultivation and decreasing profits associated with conventional transplanting practices. It provides several advantages, including labor and water savings, reduced drudgery, early crop maturity, lower production costs, and improved soil physical conditions for subsequent crops, reduced methane emission, and versatility in various cropping systems. DSR is a cost and labor-saving technology, and with proper management practices, it can achieve similar or even higher yields compared to conventional transplanting. The higher grain yield of DSR is mainly attributed to factors such as increased panicle number, higher thousand-grain weight, and lower sterility percentage. Due to differences in crop sowing method and land preparation, labor requirements in DSR are lower, resulting in labor savings of 13-29% compared to conventional transplanting.

Direct seeding of rice has offer higher number of benefits to farmers and the environment compared to conventional puddling and transplanting practices. These benefits include labor savings (1-2 laborers compared to 25-30), faster and easier sowing within a specified timeframe, and support of 7-10 days early crop maturity which permits timely planting of subsequent crops, more efficient water use, and increased tolerance to limited water availability.

Need of Women Friendly Sowing Tool in DSR

The research findings reveal that the total cost of cultivating rainfed paddy amounted to Rs. 26,330.65, with fixed costs constituting 19.02% (Rs. 5,007.20) of the total cost, and variable costs comprising 79.92% (Rs. 21,043.45) of the total expenditure. The achieved grain yield stood at 15.23 quintals per acre, yielding gross returns totaling Rs. 34,689.78, inclusive of returns from both the main product (grain) and by-product (straw). Rainfed paddy cultivation resulted in a net return of Rs. 8,359.13, with returns over variable costs amounting to Rs. 13,367.33. The returns per rupee of expenditure were calculated at 1.32. The study suggests that rainfed paddy cultivation entails lower cultivation costs, enabling farmers to attain improved income. Furthermore, it supports better crop establishment, leading to enhanced yield parameters and ultimately higher productivity, resulting in increased net income from rainfed paddy cultivation.

SPECIFICATION OF WOMEN FRIENDLY MODIFIED DRY DRUM SEEDER

- Row to Row Spacing: 20 cm
- Number of Rows: 8
- Shape of Seed Drum: Hyperboloid
- Seed drum diameter: 20 cm
- Number of Seed drums: 4
- Seed metering holes diameter: 9 mm
- Number of holes in each drum: 12 holes
- Sowing capacity Per hole: 2-3 Seeds
- Capacity per drum: 2 Kg with overall capacity of 8kg
- Diameter of Wheel: 60 cm
- Seed drum and Wheel: Plastic
- One square shaft, a handle base, and a handle

- Machine Weight: 10 Kg (Approx)
- Soil covering attachments (4 covering blade with frame and handle)
- Able to complete sowing of 1 acre within one hour by involving 2 women labour
- Minimum coverage of 5-8 acre/day by involving 2 women labour.

BENEFITS OF WOMEN FRIENDLY SEED DRILL IN DRY SEEDINGS

Among various seed drills used for direct seeding (viz., conventional seed cum fertilizer drill, zero till drill, Inverted T-tyne zero-till seed - cum-fertilizer drill, Vertical plate metering mechanism and inclined plate metering mechanism), machines with inclined plate metering mechanism are most suitable for DSR. Modified dry drum seeder is another women friendly tool which can be accommodated in dry seeding in rice by having the benefits as below:

- Savings in cost of sowing - Rs. 600/acre
- Savings of seed - 10 kg/acre; Rs. 430/acre
- Additional yield obtained - 600 kg/acre; Rs. 12,600/acre
- Total benefits - Rs. 13,630/acre
- Employment opportunity for women labour

Conclusion

Rainfed rice cultivation productivity depends on the higher germination and maintaining optimum plant population and profitability depends on reduction in cost of production and enhancing the yield and net income. Women friendly dry seeder for rice under rainfed system provides employment opportunity for the women folk, complete the timely sowing by the small and marginal farmers and results in higher rice production and higher water productivity with low risk in rainfed rice cultivation.

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FARMING FUTURES: HARNESSING AGROTOURISM FOR SUSTAINABLE DEVELOPMENT

Article ID: AG-V04-I04-86

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Introduction

Agro-tourism, sometimes referred to as agri-tourism, is a centuries-old tradition rather than a recent idea. People have travelled to farms and rural areas for recreational and educational purposes throughout history. The transformation of agricultural fields into vibrant agritourism destinations stands out as a significant trend within the diverse spectrum of tourism, particularly in rural areas. This innovative approach not only provides an escape from urban hustle but also immerses visitors in the heart of agricultural life. Agritourism sites serve as gateways for guests to engage directly with farming practices, indulge in farm-to-table cousins, and embrace the rural lifestyle. By seamlessly blending entertainment and education, these destinations not only promote sustainable agricultural practices but also forge deeper connections between food producers and consumers. Moreover, agritourism injects vitality into local economies by fostering the growth of small businesses and offering farmers additional streams of income, thus contributing to the revitalization of rural communities. Consequently, the symbiotic relationship between tourism and agriculture presents a promising avenue for sustainable development and the rejuvenation of rural areas. Inviting visitors to tour farms, ranches, or other agricultural businesses for the goals of amusement, education, and financial support for the farm, ranch, or business owner, it is a novel business model that combines agricultural production and processing with tourism.

Definition

Agro-tourism is defined as travel, which combines, agriculture and rural setting with a product of agriculture operation all within a tourism experience. The experience itself is the Agro-tourism product, besides Tourists can buy fresh Agricultural produce and products directly from farmers without any middle man (agents). This definition was given by Pandurang Taware who is also known as the father of agro-tourism in India.

History

The term "agro-tourism" finds its roots in Italy, where in the 1970s and 1980s, the concept of "agriturismos" gained popularity as a means to experience rural life by lodging on farms. This trend emerged as a favoured way to explore the countryside, offering visitors an authentic agricultural experience while contributing to the local economy. In Italy, the business model is commonly referred to as "Agriturismos," highlighting its fusion of agriculture and tourism. Similarly, in Britain, Australia, and New Zealand, it is known as "farm stay holidays," emphasizing the opportunity for visitors to stay on working farms and engage in agricultural activities. This global adoption of agro-tourism underscores its appeal as a way to connect consumers with the origins of their food while supporting local farmers and rural communities.

The first agro-tourism center was constructed in the Indian state of Maharashtra, where the notion of agro-tourism initially gained traction. Since then, Maharashtra has seen a sharp rise in the quantity of these centers. There are currently about 350 agrotourism destinations in Maharashtra alone, and this number is expected to rise in the future. A graduate in agriculture, Chandrashekhar Bhadsavle is one of the pioneers in this field; he opened the 'Saguna Baug' agro-tourism center in 1985. Lying in natural surroundings, 'Saguna Baug' provides a wide array of experiences, such as rice plantations, fish harvesting in farm lakes, and the cultivation of coconut, mango, chickoo (sapodilla) trees, among other fruits and vegetables.

The Agro-tourism Development Corporation (ATDC), based in Baramati, Maharashtra, was founded, sowing the first seeds of agro-tourism in India. The Agro-Tourism Concept's founder, Pandurang Taware, founded ATDC in 2004 with the goal of transforming rural tourism. Under Taware's direction, ATDC launched the Pilot Project of Agri-Tourism in Malegaon, close to Baramati, Maharashtra, on May 16, 2005, demonstrating the potential of agricultural tourism on the farm of the Agriculture Development Trust. This was the organization's first major move. The experimental project blossomed into a huge success in just two years. Building on this success, the Maharashtra State Agri-Tourism Vistar Yojana 2007 was introduced by ATDC in 2007 and selected 52 farmers to open agri-tourism destinations around Maharashtra. The goal of this project was to increase the number of farmers who could benefit from agri-tourism, especially those with small landholdings. Then, in 2008, another twenty-five farmers were selected, making seventy-two active agritourism facilities in Maharashtra.

Agro tourism activities

On-Farm Activities

- ✓ Farm Tours
- ✓ Pick your produce (pumpkin picking patches , cut-your-own Christmas tree farms , Fruits and vegetables picking , Flower picking)
- ✓ Wine yard tour
- ✓ Gardening activities
- ✓ Corn maze
- ✓ Human puddle
- ✓ Petting and feeding zoo
- ✓ On-farm farmers' markets
- ✓ Harvest festivals
- ✓ Farm Stays
- ✓ Agricultural Work Experiences
- ✓ Educational Workshops (Livestock , Honeybee , Mushroom cultivation , Silkworm , Fishery , Organic farming , ITK)

Tractor ride

Farm tours

Off-Farm Activities

- ✓ Farm-to-Table Cooking Classes
- ✓ Boating
- ✓ Cycling
- ✓ River rafting
- ✓ Fishing
- ✓ Hiking
- ✓ Bullock cart ride
- ✓ Cannery tours
- ✓ Events (concerts)
- ✓ Exhibitions
- ✓ Farm to table meals

SCOPE OF AGRI-TOURISM IN INDIA

Agro-tourism is a singular chance to experience genuine rural living, sample regional cuisine, and learn about a range of agricultural pursuits. The importance of agro-tourism cannot be emphasized, since agriculture is the backbone of the Indian economy, employing around 26% of the country's GDP and supporting over 75% of the population either directly or indirectly. India's farming culture is strongly rooted in the country's culture, with 90 million farmers living in 6.25 lakh villages and producing the nation's staple foods. Therefore, increasing the amount of money generated by agriculture through other ventures like agro-tourism has the potential to increase agriculture's share of the national GDP.

Recognized as a driver of job creation, poverty reduction, and sustainable human development, tourism has been essential to the socioeconomic growth of India. During the 1999–2000 fiscal year, 15.5 million employment were directly created by tourism. Additionally, tourism encourages local handicrafts and cultural activities while also fostering national integration and global understanding. India received 26.41 lakh foreign visitors in 2000, however its 0.38 percent share of the world tourism sector is still quite small. In spite of this, tourism generated foreign exchange gains of Rs. 14,475 crores. Interestingly, domestic tourism turnover is far higher than this number.

To further promote tourism, initiatives identified by the Government of India include infrastructure development, product enhancement, expansion, eco-adventure sports promotion, cultural showcases, provision of affordable accommodation, streamlining airport services, human resource development, raising awareness, public engagement, and fostering private sector collaboration. These measures aim to harness the full potential of tourism, thereby driving economic growth, fostering cultural exchange, and showcasing India's rich heritage and natural beauty to the world.

BENEFITS OF AGRO-TOURISM TO THE FARMERS

- Expanding cultivate operations
- Utilizing cultivate based items in a modern and inventive way
- Improving farm income streams
- Creating new buyer market niches
- Expanding awareness of nearby agrarian products
- Expanding appreciation of the significance of maintaining rural land
- Channeling extra on-farm incomes directly to family members
- Improving cultivate living conditions, working regions & cultivate diversion opportunities
- Creating administrative expertise and entrepreneurial soul

THE ROLE OF AGRO-TOURISM IN SUSTAINABLE DEVELOPMENT

Economic Benefits

Agro-tourism plays a crucial role in supporting sustainable economic development, particularly in rural communities. By diversifying income sources, creating job opportunities, and fostering local entrepreneurship, agro-tourism contributes to the resilience and vitality of these regions. The market for agro-tourism is expected to experience substantial growth, offering significant opportunities for economic empowerment. Through offerings such as farm stays, tours, workshops, and events, farmers can generate additional revenue streams, reducing reliance on traditional agriculture and promoting economic diversification. Moreover, the development of agro-tourism can stimulate demand for various goods and services within the community, benefiting local businesses and contributing to overall economic prosperity.

Social and Cultural Impacts

Agro-tourism serves as a platform for preserving cultural heritage, fostering community engagement, and promoting cultural exchange. By showcasing local customs, traditions, and culinary practices, agro-tourism offers tourists insights into diverse ways of life and promotes mutual respect and understanding. Personal interactions between tourists and locals facilitate meaningful cultural exchange, enriching both parties' experiences. Additionally, agro-tourism provides opportunities for culinary experiences, allowing visitors to savor authentic local dishes and learn about their cultural significance. Through these activities, agro-tourism promotes cultural appreciation and enhances the overall travel experience.

Environmental Sustainability

Agro-tourism plays a vital role in promoting environmental sustainability by encouraging sustainable agricultural practices, conservation efforts, and biodiversity preservation. By promoting sustainable land use practices and environmental stewardship, agro-tourism helps protect natural habitats, wildlife, and biodiversity. Moreover, supporting regenerative agriculture through agro-tourism can contribute to carbon sequestration and mitigate the impacts of climate change. By promoting a deeper understanding of the interdependence between agriculture and the environment, agro-tourism facilitates sustainable development and fosters a harmonious relationship between people and the planet.

Conclusion

In conclusion, agro-tourism emerges as a multifaceted solution to the challenges of sustainable development, offering economic, social, and environmental benefits. Through the diversification of income sources, creation of job opportunities, and stimulation of local economies, agro-tourism empowers rural communities and promotes economic resilience. Furthermore, by fostering cultural exchange, preserving cultural heritage, and promoting mutual understanding, agro-tourism enriches the travel experience and strengthens social cohesion.

Importantly, agro-tourism also serves as a catalyst for environmental sustainability, promoting sustainable agricultural practices, conservation efforts, and biodiversity preservation. By harnessing the potential of agro-tourism, communities can achieve holistic and inclusive development, fostering prosperity, cultural enrichment, and environmental stewardship for present and future generations.

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HARNESSING GENETIC VARIATION IN CROP IMPROVEMENT

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Abstract

Utilizing genetic variation in plant breeding revolutionizes crop improvement, enhancing productivity, resilience, and nutritional quality. Recent advances in genomics and biotechnology accelerate the identification and utilization of genetic diversity. Traits like early maturity and resistance genes ensure yield stability and resilience to stresses like drought. Biofortification programs target nutrient deficiencies, promoting human health and well-being. Integration of multi-omics data enriches our understanding of trait expression regulation. Exploration of wild genetic resources enhances adaptability to changing environments. Harnessing genetic diversity is crucial for sustainable agriculture and global food security.

Introduction

In plant breeding, genetic variation is the cornerstone of crop improvement, offering a diverse array of traits that can be leveraged to develop resilient, productive, and nutritious crop varieties. Recent advances in understanding genetic variation in plants have revolutionized crop improvement efforts, providing new insights and tools to enhance agricultural productivity, sustainability, and resilience.

Enhanced Productivity and Yield Stability

Genetic variation within crop species provides breeders with a diverse array of traits that contribute to enhanced productivity and yield stability (Huang *et al.*, 2012). Traits such as early maturity, increased biomass production, and improved nutrient utilization enable crops to thrive under optimal growing conditions. Furthermore, genetic variation allows for the development of crop varieties with broader adaptability to different agroecological zones, reducing the risk of crop failure and ensuring food security.

Resilience to Biotic and Abiotic Stresses

Genetic variation is crucial for developing crop varieties resilient to biotic and abiotic stresses (Leakey & Lau, 2020). Through the identification and introgression of resistance genes, breeders can develop crops that withstand pests, diseases, and environmental stresses such as drought and salinity. Traits such as deep root systems and efficient water use enable plants to maintain growth and productivity under adverse conditions, ensuring a stable food supply in regions prone to climatic extremes.

Nutritional Quality and Human Health

Genetic variation plays a vital role in enhancing the nutritional quality of crops, contributing to human health and well-being (Tiffin & Ross-Ibarra, 2014). Biofortification programs aim to increase the levels of essential nutrients in staple food crops, addressing nutrient deficiencies prevalent in vulnerable populations. Moreover, breeding for reduced levels of anti-nutrients and allergens enhances the nutritional value and marketability of crop products, promoting a healthier and more sustainable food system.

Innovation in Breeding Technologies

Advances in molecular biology, genomics, and biotechnology have revolutionized crop improvement efforts, accelerating the identification and utilization of genetic variation (Varshney *et al.,* 2014). High-throughput sequencing technologies enable rapid analysis of plant genomes, facilitating the identification of genetic variants underlying important agronomic traits. Genome editing techniques offer unprecedented opportunities for precise manipulation of plant genomes, overcoming breeding barriers and introducing novel genetic variations directly into elite cultivars.

Recent Advances in Understanding Genetic Variation

Recent research has further advanced our understanding of genetic variation in plants (Huang *et al.,* 2012; Leakey & Lau, 2020). Multi-omics integration has provided comprehensive insights into the functional implications of genetic variation, enabling breeders to decipher complex regulatory networks governing trait expression. Exploration of wild genetic resources has enriched the genetic diversity of cultivated crops, enhancing their adaptability to changing environmental conditions.

Conclusion

In conclusion, harnessing genetic variation is essential for crop improvement, offering opportunities to develop crops with enhanced productivity, resilience, and nutritional quality. Recent advances in understanding genetic variation, coupled with innovative breeding technologies, are driving progress towards sustainable agriculture and food security. By leveraging the inherent diversity present within crop species, we can unlock the full potential of genetic variation to address the challenges facing global food systems.

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SEEDING INNOVATION: EXPLORING THE IMPACT OF MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE IN SEED SCIENCE AND TECHNOLOGY

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Abstract

Machine learning (ML) and artificial intelligence (AI) are driving innovation across various industries, aiming to improve efficiency and solve complex problems. In the field of seed science and technology, the integration of AI and ML has ushered in a new era of advancements, revolutionizing processes from seed selection to crop management. This article explores the transformative potential of AI and ML in seed science, highlighting their role in enhancing seed quality assessment, accelerating breeding programs and optimizing crop management strategies. By harnessing data-driven insights, these technologies offer promising solutions to global food security challenges and pave the way for sustainable agricultural practices.

Keywords: *Seed science, Artificial intelligence, Machine learning, Crop management, Sustainable agriculture*

Introduction

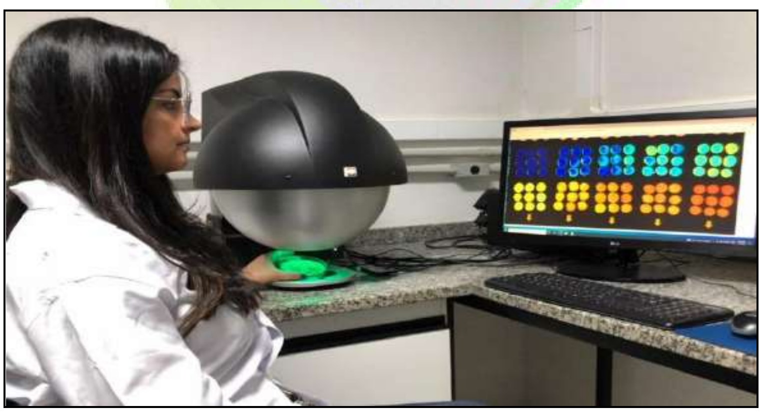
Machine learning involves algorithms that learn patterns from data to make predictions or decisions, while artificial intelligence aims to create intelligent systems capable of human-like tasks. Both fields drive innovation across industries, with machine learning focusing on data-driven learning and artificial intelligence aspiring to emulate human intelligence. Their impact spans diverse sectors, from healthcare and finance to transportation and agriculture, revolutionizing processes and enabling solutions to complex problems. As technology advances, the synergy between machine learning and artificial intelligence continues to shape the future, ushering in a new era of automation, efficiency and intelligence in various domains. (Mukhamediev *et al.* 2022).

In seed science and technology, which have long been the bedrock of agricultural progress, the integration of machine learning (ML) and artificial intelligence (AI) has ushered in a new era of innovation. These advancements have transformed processes ranging from enhancing seed quality assessment to revolutionizing breeding programs. AI-driven solutions are reshaping the landscape of seed science and technology, facilitating the development of high-yielding and resilient crop varieties.

Applications of Machine Learning and AI in Seed Science and Technology

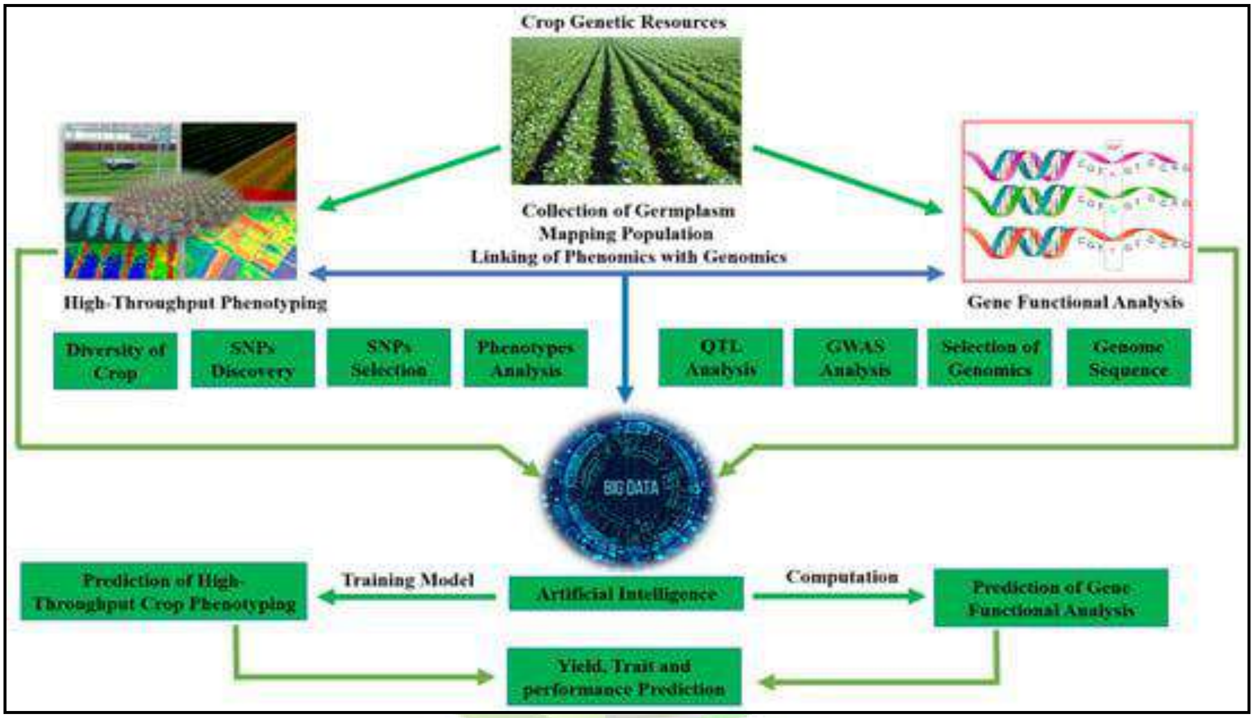
Enhancing Seed Quality Assessment

Seed quality assessment is a critical aspect of seed science, influencing crop establishment, vigor, and yield potential. Traditionally, assessing seed quality involved labor-intensive and subjective methods. However, with the advent of machine learning algorithms, this process has been revolutionized. By analyzing vast datasets encompassing genetic information, environmental parameters and phenotypic traits, AI can accurately predict seed quality parameters such as germination rate, vigor and disease resistance (de Medeiros *et al.* 2020, Fan *et al.* 2020). This data-driven approach enables seed scientists to identify genetic markers associated with desirable traits, facilitating the development of superior seed varieties tailored to specific environmental conditions and agricultural requirements.



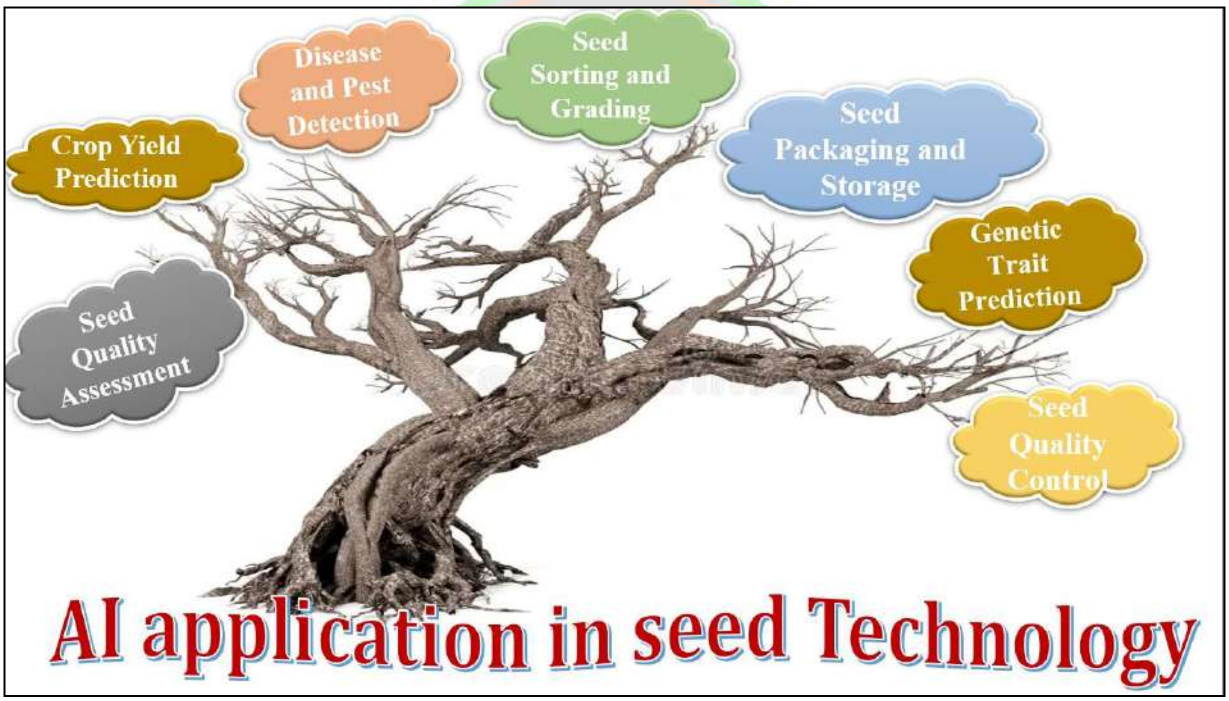
Accelerating Breeding Programs

Breeding new crop varieties with desired traits is a time-consuming process traditionally reliant on trial and error. However, machine learning and artificial intelligence techniques have expedited this process significantly. By leveraging predictive modeling and genomic analysis, AI algorithms can sift through vast amounts of genetic data to identify candidate genes linked to desirable traits. This accelerates the selection of parental lines and progeny with desired characteristics, ultimately shortening breeding cycles and increasing breeding efficiency. Additionally, AI-driven breeding programs optimize hybridization and genome editing techniques, enhancing traits such as yield, stress tolerance, and nutritional content. By leveraging AI, seed scientists can develop resilient crop varieties adapted to changing climatic conditions and evolving market demands more rapidly than ever before.



Precision Agriculture and Seed Placement

Precision agriculture relies on data-driven decision-making to optimize resource use and maximize crop productivity. AI plays a pivotal role in this regard by integrating data from various sources, including satellite imagery, drones and IoT sensors (Akhter, R. and Sofi, S. A. 2022). By analyzing spatial variability in soil properties, climate conditions and crop health indicators, AI generates precise seeding maps and recommends optimal seed placement strategies. Additionally, AI-powered machinery enables precise seed placement and planting density adjustments, ensuring uniform crop establishment and maximizing yield potential. This precision not only enhances resource efficiency and minimizes input costs but also mitigates environmental impact, promoting sustainable agricultural practices.



Challenges and Future Directions

Data Accessibility and Quality

Ensuring the availability of high-quality, diverse datasets is imperative for training accurate machine learning (ML) and artificial intelligence (AI) models in seed science and technology. Challenges may emerge concerning data collection, standardization and privacy. Collaborative efforts among stakeholders are necessary to address these challenges. By establishing data-sharing protocols, standardizing data formats and implementing privacy safeguards, the seed science community can overcome data-related obstacles and unlock the full potential of AI and ML.

Regulatory Considerations

Ethical and regulatory frameworks must be developed to ensure the responsible adoption of AI and ML technologies in seed science. Issues such as data privacy, intellectual property rights and algorithmic bias require careful consideration and transparent governance. Policymakers, researchers and industry leaders must collaborate to establish guidelines that protect data privacy, promote fair use of intellectual property and mitigate the risks of algorithmic bias. By adhering to ethical standards and regulatory guidelines, the seed science community can foster trust and confidence in AI and ML technologies.

Interdisciplinary Collaboration

Successful integration of AI and ML into seed science and technology hinges on interdisciplinary collaboration. Researchers, breeders, technologists, and policymakers must work together to leverage diverse expertise and perspectives. Interdisciplinary teams can address complex challenges more effectively, drawing on insights from fields such as genetics, agronomy, computer science, and ethics. By fostering a culture of collaboration and knowledge-sharing, the seed science community can harness the synergies of AI and ML to drive innovation and address global food security challenges.

Future Directions

Continued research and innovation in AI and ML hold promise for further advancements in seed science and technology. As technology evolves, new opportunities will emerge to enhance seed selection, breeding programs and crop management strategies. Embracing sustainable practices and addressing ethical considerations will be critical in shaping the future of agriculture. By prioritizing sustainability, equity and ethical governance, the seed science community can harness the transformative power of AI and ML to create a more resilient and food-secure future for generations to come.

Conclusion

The integration of machine learning and artificial intelligence has ushered in a new era of innovation in seed science and technology. By leveraging AI-driven solutions, seed scientists can enhance seed quality, accelerate breeding programs and optimize agricultural practices. As AI continues to evolve, its integration into seed science holds promise for fostering resilience, sustainability and innovation in crop production, ultimately shaping a more food-secure and prosperous future for generations to come.

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BLACK PEPPER PRODUCTION UNDER ORGANIC FARMING IN AGRO FORESTRY SYSTEMS

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Introduction

Black pepper is one among the most valued spice crops cultivated mostly in Kerala, Karnataka and to a limited extent in Tamil Nadu and other north eastern states. India is the largest producer and consumer of spices in the world with an area and production of 2.59 lakh hectares and 61,000 tonnes, respectively during 2019-2020. Black pepper is affected by several obnoxious pests as well as diseases which leads to severe crop losses. Agrochemicals that are commonly used to manage the pests and diseases are harmful to the environment, adversely affects soil ecosystem especially the beneficial microorganisms, ground water contamination etc. Due to undesirable results and being need of the hour, is to adopt safer environment friendly management methods of black pepper cultivation is suitably expected. In this back ground, organic farming is one of the options for environment friendly methods of cultivation.

Organic farming is an eco-friendly agricultural practice followed to maintain the inherent neutrality of the ecosystem without application of inorganic fertilizers, agrochemicals like pesticides, fungicides, weedicides, synthetic growth regulators and hormones and genetically modified crops. Organic farming does not only aims at attaining higher crop yield or returns but also developing long-term self sustainable practices. The yield level realized in organic farming might be less, pest and disease problem may be comparatively higher. However there are evidences of organic farm produce having better quality attributes and above all, food safety attributes.

The organic farming process is more eco-friendly than conventional farming. Organic farming keeps soil healthy and maintains environment integrity thereby, promoting the health of consumers. Moreover, the organic produce market is now the fastest growing market all over the world including India. Organic agriculture promotes the health of consumers of a nation, the ecological health of a nation, and the economic growth by income generation holistically. India, at present, is the world's largest organic producers and with this vision, we can hope that encouraging organic farming in India can build a nutritionally, ecologically, and economically healthy nation in near future.

Significance of organic farming in black pepper: Focus on sustainable pest and disease management

- Natural enemies can be encouraged to manage pests, diseases and nematodes in organic cultivation.
- Application of locally collected cow urine, FYM, vermicompost, animal input, beneficial micro organism and spray of neem seed kernel extracts etc.,
- Encourage the mulching of locally available plant materials which can able to control disease and weed also.
- Management of disease and nematodes through cultural practices, use of resistant variety, biological agents and botanicals, green manuring, compost and natural fertilizers (bone meal, rock phosphate etc).

Basic approaches in organic farming for sustainability includes the following,

1. Improvement and maintenance of the natural landscape and agro-ecosystem.
2. Avoidance of overexploitation and pollution of natural resources.
3. Minimization of the consumption of non-renewable energy resources.
4. Exploitation synergies that exist in a natural ecosystem.
5. Maintenance and improvement in soil health by stimulating activity or soil organic manures and avoid harming them with pesticides.

Augmenting production potential in black pepper through organic farming: perspectives for Parambikulam region

Parambikulam region is already an isolated place from main land cultivation which is located in tiger reserve forest. The people living in the area are tribal communities, who are cultivating black pepper as a predominant mono crop. They are naturally cultivated without applying any synthetic agrochemicals. The entire produce are residue free, safe and nutritious which has attracted preference of the consumers, even in the local nearby markets increasing the demand for organically produced food products. The cultivation of pepper by the households was promoted by the active intervention of the Forest depart6ment of Kerala as a part of the Eco development project and policies. The entire plantations jointly cultivated by tribal families were provided with organic certification.

The Poopara hamlet is situated at Poopara hills near Parambikulam forest reserve and a few other villages are also present within Parambikulam Tiger Reserve, Muthalamada block, Palakkad district, Kerala. The tribal colony comprises of about 54 families who are cultivating mainly black pepper and some other crops like arecanut, coffee and nutmeg which immensely supports their livelihood. The colony spans around 70 acres of which 65 acres are being utilized for agriculture related activities. The black pepper (majority belonging to the variety Panniyur 1), which is the major money minting crop cultivated, are trailed mainly on Glyricidia and Erythrina standards or forest trees.

Prospects

The long-term economic viability and sustainability in agriculture can be achieved only by organic farming and prevalence of natural farming in those regions. So it should be protected and promoted as such. The land is having features such as fertile soil (more response to organic practices), having desired isolation distance, relatively protected from endemics. Farmers usually apply less external agricultural input and, therefore under promotion of organic certification so that organic farming can be more profitable. They are assisted by the forest department for premium price in the local as well as distant markets.

Issues

Farmers 2018 onwards faced many constraints such as disease, pests and nematodes gradually spreading to large area of crop, Lack of awareness of farmers and inadequacy of extension services resulted in severe crop and yield loss to the farmers. The intervention of ICAR IISR along with Department of Agriculture, Govenmnt of Kerala carried out systematic filed surveys to assess the problems. It was revealed that major problems were yellowing of vines, wilting and drying of leaves, root lesions, rotting on collar region and roots and dying of plants. The timely adoption of prophylactic or disease amangment measures was not possible.

Fig-1. Slow decline and foot rot diseases affected black pepper plot in parambikulam

Recommendation for sustaining the system:

Survey observations were recorded and soil and plant samples were tested for further renovation of the cropping system and long term sustainability. Following recommendations were given,

(1) Foot rot

- Phytosanitation: Removal and burning of wilted vines along with root system to reduce inoculum build up.
- Avoidance of injury to the root system during cultural operations like digging.
- Runner shoots: Freshly emerging runner shoots should not be allowed to trail on the ground. They must either be tied back to the standard or pruned off.
- Shade tree regulations: The branches of support trees must be pruned with the onset of monsoon to avoid build up of humidity.
- Permissible chemical control: After the receipt of few monsoon showers (May-June), foliar spray with Bordeaux mixture (1%) is to be given. Spraying should be repeated again during August-September.

- Biological control: At the onset of monsoon (May-June), apply *Trichoderma* around base of the vine @ 50 g/vine (this quantity is recommended for a substrate containing *Trichoderma* @ 10^{10} cfu). The bioagents may also be mass multiplied in appropriate organic substrates like farmyard manure and applied to the vines.

(2) Slow decline

- Severely affected vines beyond recovery should be removed and destroyed.
- Apply *Pochonia chlamydosporia* or *Trichoderma harzianum* @ 50g/vine twice a year (during April-May and September-October). The fungus load in the substrate should be 10^8 cfu/g.
- Application of Neem cake @ 500g/plant can be applied

(3) General recommendations for nutrient management

- Application of P needs to be skipped for 1 or 2 seasons.
- Apply black pepper micronutrient @ 5g per litre as foliar spray during May-June and August-September.
- Application of dolomite application @ 500g per standard at required site.
- Apply organic manures as cattle manure or compost @ 10kg/vine during May.
- Apply lime @ 500g/vine in April-May during alternate years.

(4) Crop diversification

Organic farming mostly to encourages the crop diversity in a same space of land to sustain and protect the multiple beneficial organisms, soil health, protect the organisms facing threat of extinction and promotion of overall farm health.

- Cultivation of black pepper as monocrop considerably increases the risk and hence to grow other trees spices like Nutmeg and Garcinia can be a profitable alternative.
- Black pepper if adopted as a monocrop system may be intercropped like green manures crops and other antagonistic plants like marigold etc., which can control pest and diseases as well as maintain soil health.
- Agricultural extension officials can make more concerted efforts to increase awareness, provide knowledge input and also provides supporting services like crop insurance, crop loan, subsidized other agricultural schemes for the exclusive benefit of the tribal farmers

- To facilitate marketing channels by agricultural extension officials to tap the demand of organic produce.

Future prospects

- The government department supported tribal hamlets and hill forest agro ecosystems like Parambikulam and Periyar Tiger reserves in Kerala are typical illustrations for organic and natural farming systems; with a potential to provide safer, healthy, nutritious and quality food produce without compromising soil health and sustainability. ICAR-IISR and department of agriculture, Kerala carried out timely interventions for imparting training to the tribal farmers on organic farming and supplied biocontrol agents for prophylactic management of foot rot and slow decline. Nutmeg as an alterative tree crop was introduced by supplying 200 grafts of improved varieties of nutmeg. Looking foreword introduction of other crops like coffee and arecanut can be considered.
- Market facilitation by the department of agriculture to get premium price and efforts to link with national and international market will help to tap the potential demand of organic produce. All these programmes should be aimed at promoting agricultural employment to the tribal families and increase their standard of living.

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EFFECTS OF GLOBAL WARMING ON AVAILABILITY OF SOIL AND WATER

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Introduction

Global warming refers to the long-term heating of Earth's surface observed since the pre-industrial period (between 1850 and 1900) because of human activities, primarily fuel burning, which increases the heat-trapping gas levels in Earth's atmosphere. The term is usually used interchangeably with the term" temperature change", which latter refers to human and naturally created warming and therefore the effects it has on our planet. The warming trend of recent times is a rapid and ongoing phase of climate change.

Humans have affected worldwide surface temperature by changing the radiative equilibrium of the Earth. The most significant and notable anthropogenic impact is the increase in concentration of ozone depleting substances in the air.

Environmental change is as of now influencing water access for individuals all over the planet, causing more extreme dry spells and floods. Climate change led by global warming is responsible for increase in worldwide temperature making water unavailable at certain places, which is prompting to more amount of atmospheric water vapor and extreme irregular rainfall patterns ,which is further followed by soil erosion that results in detoriation of the upper soil surface causing loss of nutrients from the top layer of soil.

Causes of global warming

The reasons for global warming can be both anthropogenic and natural as discussed below

Natural Causes: The world's environment is dynamic and continuously changing through a natural cycle. The environmental changes are being considered by researchers all around the world who are observing through proof from tree rings, dust tests, ice centers and ocean silt. There are various normal variables responsible for environmental change. Most frequent among those are volcanoes, ocean currents, the earth's tilt, comets and shooting stars.

Anthropogenic causes:

Human-caused a worldwide temperature alteration which is frequently called anthropogenic environmental change. Industrialization, deforestation and contamination have extraordinarily expanded climatic convergences of water vapor, carbon dioxide, methane and nitrous oxide, all ozone harming substances that assist in trapping heat close to earth's surface. Humans are releasing carbon dioxide into the atmosphere a lot quicker than plants and seas can assimilate it. These gases remain in the environment for a really long time; hence the small efforts put forth by the people would not quickly stop a worldwide temperature alteration.

Greenhouse gases: Our planet is made by the presence of specific gases which trap long-wave radiation produced from the world's surface, giving a worldwide mean temperature of 15°C instead of an expected - 18°C without a trace of an atmosphere.

Global Warming and Soil

Soil is the second biggest natural carbon sink, after ocean, outstanding forest and other vegetation, it has ability to sink carbon dioxide from the atmosphere .These facts remind us how significant soil is, not only for our food production but also for helping us to combat with the most terrible impacts of climate change.

Influence of global warming on soil

1. The rise in average temperature and irregular rainfall patterns due to global warming is detoriating the soil health by reducing the soil moisture.
2. As the soil moisture is reducing there is an increase in artificial irrigation practices which additionally result in excess water usage hence resulting in scarcity of water.
3. Intense rain, extreme heat waves, irregular drought and frequent storms assist in soil erosion.
4. Rising sea level is leading to change in the chemical properties of soil in the coastal areas by frequent addition of salts and extra minerals ,making the area less productive.
5. With worldwide temperature increase permafrost melting can be another issue as melting causes disintegration of the material trapped in the frozen soil, leading to release of massive amount of greenhouse gases into the atmosphere, which could lead to global warming beyond our control.

Better soils and land ecosystem could absorb and store more carbon dioxide from the atmosphere than they as of now do. Soil alone can't fix climate change however it should still be considered as a supporting factor to reduce greenhouse gas emission. A lot stays undiscovered, however the more we understand the elements between soil, land and the environment, the more are our possibilities of planning and carrying out sustainable solutions

Global Warming and Water

Global warming is influencing water access for individuals all over the planet, causing extreme dry seasons and irregular floods. Increased earth temperature is one of the principal contributors of this issue. Climate change and global warming impacts the water cycle by affecting the rate and intensity of rainfall. It leads to more serious weather events. Increased global temperature makes water evaporating rate faster and in larger amounts, which increases atmospheric water vapor leading to more frequent, heavy, and intense rains in the coming years.

Agriculture crop failure due to water scarcity influences rural economy. In most parts of the rural India, life of people depends upon agriculture sector.

Disasters like floods and drought cause anxiety among small farmers. As a result, huge number of farmers in India ended their life in recent years.

The World Health Organization cautions that increasing irregular rainfall patterns are going to influence the supply of freshwater. An absence of healthy water can lead to unhygienic conditions and increases the rate of diarrheal sickness, which killed more than 500,000 youngsters consistently. The World Economic Forum has ranked water emergency as number one in worldwide risks, with potential to cause harm to financial and social effects across whole nations and areas.

Living with environmental changes mean adapting to the ill effects of it on water, and doing whatever it may take to decrease the vulnerabilities caused to communities and with hold the economy strong in such situations.

1. Extreme weather and change in water cycle patterns are making it harder to get safe drinking water, particularly for the most vulnerable kids.
2. Around 74% of natural disaster events happened somewhere in the year of 2001 and 2018 were water-related, including dry seasons and floods.
3. The re-occurrence and destruction caused by such events are simply expected to increase with environmental changes.

4. Millions of youngsters live in areas prone to high-water stress. This implies that they require more water to full fill their basic needs.
5. Whenever disaster may hit, it can destroy or contaminate whole water supplies, increasing risk of sicknesses like cholera and typhoid to which youngsters are easily prone to .
6. Rising temperatures can prompt lethal microbes in freshwater sources, making the water contaminated for drinking purpose.
7. Water borne diseases are one of the main sources of death in kids under 5 years of age.
8. Even in today's world kids die from loose bowels due to insufficient water, sterilization and cleanliness.
9. Environmental change led to water stress in areas with high population and limited water availability which gives rise to clashes for water.
10. Rising ocean levels are making fresh water become pungent, leading to the lack of freshwater on which huge numbers of individuals depend on.

Conclusion

Global warming cannot be blamed on individuals; however, it can be tackled and maintained from worsening starting at the individual level. Of course, industries and multinational conglomerates have higher carbon emissions levels than an average citizen. Still, activism and community effort are the only feasible ways to control the worsening state of global warming.There are numerous things that everybody can do to reduce the effect of climate change. It may include growing our own fruits and vegetables or purchasing locally grown rather than purchasing from market since they are transported to supermarkets from a long way off by trucks, which add more carbon dioxide to the climate.

We could likewise walk or ride a bicycle and oppose driving a vehicle or use public transportation. For a bigger scope, enterprises that are reliant upon petroleum products need to switch to inexhaustible, cleaner energy sources that are better for our planet. Various adaptation strategies can be adapted like changes in crop varieties, applying developed dry farming techniques, further develop water management, growing more productive irrigation system, and changes in planting can prove to be significant in restricting unfavorable impacts and beneficial for valuable changes in climate.

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MILLETS: A POWER HOUSE OF HEALTH BENEFIT

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Introduction

MILLETS are among the oldest crops to be domesticated and cultivated by humans and have been a vital component of dry farming system in several Asian and African countries. Fine cereals including wheat and rice are generally preferred for human consumption, and millet grains have often been neglected since long. However, these 'orphan crops' remain staple food and source of nutrition to the resource-constrained farmers inhabiting arid and semi-arid tropics. Of late, with climate change and malnutrition becoming major concerns across the globe, millets have started to regain their significance owing to their nutritional quality and climate smart nature. Millets include the major and small millets where sorghum and pearl millet are the major millets and finger millet, foxtail millet, little millet, proso millet, kodo millet, and barnyard millet are the important small millets. These millet grains are nutrient-dense and exhibit nutraceutical properties. Also, these grains are utilized as bird feed in several countries including the United States. Apart from being nutritionally superior, these crops also exhibit several agronomic benefits including the ability to grow under harsh environmental conditions, resistance to biotic and abiotic stress, and shorter growing periods. Owing to these benefits, millets are now regarded as 'smart foods' which are good for the farmer, consumer, and the environment.

Why one should eat millets?

Millets are free of gluten, very nourishing, and high in nutritional fibre. They are abundant in micronutrients including calcium, iron, phosphorus, and other elements. Due to their low glycemic index (GI), they don't significantly raise blood sugar levels. Idealistically, millets ought to be a staple of our daily diet. Millets' dietary fibre has the ability to bulk up and absorb water. It lengthens the time that food travels through the gut, which lowers the risk of inflammatory bowel disease and serves as a cleansing agent for the body.

Advantages

- It targets low-income people and rural communities, and remote areas like tribal regions.
- Its recurrent costs are low; therefore bio-fortified varieties can be grown by farmers without extra cost and seeds can be shared.
- It is sustainable as its varieties will continue to be grown and consumed year after year.
- It provides a long-term strategy of delivering more micronutrients, and is a powerful intervention tool to alleviate micronutrient malnourishment.

Millets are nutri-cereals

• Millets are highly nutritious compared to fine cereals like rice

. Millet grains contain high protein, fibre, micro and macronutrients and are gluten free.

• Millet protein has well balanced amino acid profile and good source of methionine, cysteine & lycine.

• Pearl millet has the highest content of fat and micronutrients.

• Sorghum is a cheap source of energy, protein, iron and zinc next only to bajra.

• Finger millet is the richest source of calcium and potassium (400–420 mg/100 g).

• Other small millets are good source of phosphorous and iron.

• Phytochemicals in many of the millets act as antioxidants.

Reasons for Negligence

Due to several inherent issues including rapid seed breaking and uneven maturation, many minor millets are not suitable to modern agro ecosystems and mechanization. In addition to these fundamental characteristics, grain size is a crucial yield factor since little millets' extremely tiny seeds make mechanized planting and harvesting difficult, and eventually prevent their commercialization. Minor millets' seeds must be dehulled before being consumed by humans. Traditional dehulling techniques used in developing nations require a lot of labour and take a long period.

For the millet production system to function well, climatic parameters including rainfall distribution and pattern, agronomic management, soil type, and soil fertility, as well as the socioeconomic situation of agricultural communities, are all crucial. The most significant biotic restrictions related to millets include the prevalence of illnesses, insect-pests, parasitic nematodes, birds, parasitic plants, and weeds. The main environmental and soil conditions that limit the growth of millet include moisture stress, nutritional stress, salinity, alkalinity, acidity, and heat stress.

In addition, the lack of focused crop improvement initiatives, the unavailability of improved seeds, the widespread cultivation of less productive and heterogeneous local cultivars, the shift toward high-value cash crops, the absence of government policies, and low farm profitability may all be contributing factors to the decline.

Nutritive value of millets

When compared to wheat and rice, millets have a higher mineral concentration. The abundance of sulphur-rich amino acids in finger millet proteins makes them special. Since millets are nutritionally far superior to both rice and wheat, they are the answer to the widespread malnutrition that plagues the Indian population.

Table 1 : Composition of small millets, wheat & rice (for 100 gms)

Grain	Protein (g)	Carbs (g)	Fat (g)	Minerals (g)	Fiber (g)	Calcium (g)	Energy (Kcal)	Thiamin (mg)	Riboflavin (mg)
Finger millet	7.3	72.0	1.3	2.7	3.6	344	336	0.38	0.21
Barnyard millet	6.2	65.5	4.8	3.7	13.6	22	300	0.30	0.09
Foxtail millet	12.3	60.2	4.3	4.0	6.7	31	351	0.42	0.19
Kodo millet	8.3	65.9	1.4	2.6	5.2	35	353	0.33	0.10
Little millet	7.7	67	4.7	1.7	7.6	7.6	329	0.41	0.28
Porso millet	12.5	70.4	1.1	1.9	5.2	8	354	0.59	0.11
Pearl millet	11.8	67	4.8	2.2	2.3	43	363	0.38	0.21
Sorghum	10.4	70.7	3.1	1.2	2.0	25	329	0.38	0.15
Wheat	11.8	71.2	1.5	1.5	2.0	30	348	0.41	0.10
Rice	6.8	78.2	0.5	0.6	1.0	33	362	0.41	0.04
SOURCE: National Institute of Nutrition (NIN), Hyderabad									

Millets are a good way to maintain a healthy lifestyle and lower your risk of developing lifestyle diseases including diabetes, hypertension, and cardiovascular disease. Millets, particularly the high fibre content, offer several nutritional, nutraceutical, and health-promoting qualities. The total dietary fibre content of millet grains ranges from 6–12%. Millets are good source of micronutrients including minerals and B-vitamins as well as phytochemicals with health benefits

Poshan pledge taken by Vice chancellor NAU & also gave their remarks.

Recent news:

Government of India had proposed to United Nations for declaring 2023 as International Year of Millets (IYOM). The proposal of India was supported by 72 countries and United Nation’s General Assembly (UNGA) declared 2023 as International Year of Millets on 5th March, 2021.

Now, Government of India has decided to celebrate IYOM, 2023 to make it peoples’ movement so that the Indian millets, recipes, value added products are accepted globally.

According to the Indian Council of Agricultural Research, millets are drought tolerant and resistant to climate change. Cultivation of millets requires less water than rice and wheat, which makes them suitable for small growers.

Future outlook

To increase agricultural revenue and nutritional security in rainfed systems, millets' value and climate resilience may be the solution. Therefore, it is imperative that we adapt to climate change by replacing specific niches of water-intensive cereal and vegetable crops with millets that can withstand drought. These crops' fibrous roots help to conserve soil, control water runoff, adapt to muddy terrain, and rebuild natural ecosystems. Millets, which are marketed as gluten-free nutri-cereal smart foods, have recently seen an increase in demand. The health and wellness sector is driving this demand, and the food business is expanding quickly. As a result, increasing millet production will benefit the typical hill farmer and contribute to the achievement of the goals of raising incomes, developing crop diversification, and preserving agro biodiversity. Whether we can sustainably, equitably, and healthily feed the estimated 9 billion people on the planet by 2050 is a major concern. Even if a person consumes enough calories, it is still possible that he may not be getting enough of the essential micronutrients, which could result in micronutrient undernourishment (Hidden hunger). Therefore, the focus of research should be on creating cultivars with increased nutraceutical value and higher stress tolerance. One of the simplest options is to find and enhance native crops that are highly adapted to the local environment, have high nutritional content, and can endure biotic and/or abiotic challenges.

Awareness programme on Millets

Millets are group of small grained cereal food crops which are highly tolerant to drought and other extreme weather conditions and are grown with low chemical inputs such as fertilizers and pesticides. Most of millet crops are native of India and are popularly known as Nutri-cereals as they provide most of the nutrients required for normal functioning of human body. Millets are classified into Major Millets and Minor Millets based on their grain size.

Ministry of Agriculture and Farmers Welfare has recognized the importance of Millets and declared Millets comprising of Sorghum (Jowar), Pearl Millet (Bajra), Finger Millet (Ragi/Mandua), Minor Millets i.e., Foxtail Millet (Kanngani/kakun), Proso Millet (Cheena), Kodo Millet (Kodo), Barnyard Millet (Sawa/Sanwa/Jhangora), Little Millet (Kutki), Brown top millet and two pseudo millets i.e., Buck- wheat (Kuttu), Amaranth (Chaulai)) as "Nutri-Cereals" for production, consumption and trade point of view

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MAJOR PHYTO-NEMATODES PROBLEMS AND THEIR MANAGEMENT ASPECTS IN SPICES

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Introduction

Spice cultivation occupies 3878 ha with a production of 8124 MT during 2017-18. Many spices are grown in India. Among them, black pepper, cardamom, turmeric and ginger are the major export-oriented crops. Generally, production and productivity in any crop depend on several factors like soil fertility, climate, incidence of pests and diseases etc. Among the pests and diseases, plant parasitic nematodes are responsible for sizable yield losses in spice crops.

Several nematodes are associated with spices. These include burrowing (*Radopholus similis*), root-knot (*Meloidogyne* spp.), lesion (*Pratylenchus* spp.), reniform (*Rotylenchulus reniformis*), lance (*Hoplolaimus* spp.), spiral (*Helicotylenchus* spp.), needle (*Longidorus* spp.), stunt (*Tylenchorhynchus* spp.) nematodes. Among these, *Radopholus*, *Meloidogyne* and *Pratylenchus* spp. cause extensive damage in spices and are a serious impediment for crop production. The yield losses due to plant parasitic nematodes are estimated to range from 37-64% in black pepper, 46% in cardamom, 45.3% in turmeric and 29% in ginger.

Burrowing nematode, *Radopholus similis*

Burrowing nematode is a migratory endoparasite. It has a wide host range that includes black pepper, coconut, banana, arecanut, coffee, ginger, turmeric, sugarcane etc. The nematodes feed on tender white feeder roots forming orange to purple colored lesions. These small lesions coalesce to dark brown patches which subsequently rot and become infected by other soil-borne pathogens. In old roots, lesions are not easily seen on the surface, but may exhibit extensive rotting at later stage. Juveniles and adult nematodes, especially females, infect plants. The nematode completes its life cycle within 20 to 25 days at 24 to 32°C. Degree of damages depends on nematode population density, soil type, temperature and availability of moisture.

Burrowing nematode is primarily attributed as the causal organism for slow wilt or slow decline disease in black pepper. These nematodes are mostly distributed all over pepper growing areas of the country causing yield losses of up to 59%. Every year an average of 20% vines perish in infected plantations. These nematodes mostly spread through rooted cuttings. Foliar symptoms of this disease are pale yellow or whitish yellow leaves that droop followed by shedding of leaves. Later, dieback symptoms appear due to decreased nutrient and water uptake which will be more pronounced during the dry season. The vine will recover during the onset of south west monsoon, showing new leaves. But in 3-5 years, the disease will reemerge and the entire vine will die. The nematode is known to interact with *Phytophthora* spp and *Fusarium solani*, which causes enhanced and quick root rot and death of black pepper vines including seedlings.

The burrowing nematode will penetrate intracellularly in cortical regions of cells and lay eggs inside roots and rhizome of ginger. The infected rhizomes become small size with sunken, water soaked areas, that turn brown. Many channels or galleries are formed due to migration path, and the infected plants exhibit yellowing of leaves and stunted growth. Initially, scattered patches of infected plants appear in the field with reduced tillering and vigor. Topmost leaves appear chlorotic with scorched tips. These plants mature and dry faster than healthy plants.

Root knot nematode, *Meloidogyne* spp.

Root-knot nematodes are widely distributed and infect a number of plants. They are sedentary endoparasites and the second stage juvenile enter through the root differentiation zone, invading the vascular cylinder. The enzymes secreted by the nematode degrade cells leading to formation of 'giant cells'. These nematodes feed permanently at one point, resulting in hypertrophy and hyperplasia condition, ultimately forming galls on surface of the roots, which will block the water and nutrient transportation. Consequently, the roots decay and decompose leading to the total loss of root system. During sunny, warm weather conditions, the plants show yellowing of leaves especially random yellowing due to infected roots. These nematodes reproduce parthenogenitically and complete their life cycle in 30 days at 25-30˚C.

They are also involved in slow decline disease of black pepper. The roots are heavily galled and the affected vines show yellowing with drooping of leaves, shedding of spikes, reduced spike and leaf size and subsequent plant death. In cardamom, root-knot nematodes are observed both in nursery and main plantation. They cause delayed and poor germination in nurseries. Nematode-infected seedlings turn yellow with narrow leaves and will have severe galling on roots. Young seedlings are more susceptible to root knot nematode and seedling mortality goes up to 40% in secondary nursery. In main plantation, foliage exhibit poor stand with yellows streak and marginal drying and yellowing and necrosis of leaf tips, thickening of veins, narrowing of leaf blade, reduced tiller number, rosetting of leaves, delayed flowering and reduced capsule size. *M. incognita* causes 46% yield loss in cardamom. In the main field, visible galls are not found in most cases. Instead, witches broom type of root is a typical symptom of this nematode. Unusually more number of roots are found with curling and irregular surface of roots devoid of root hairs.

In turmeric also typical root galls are seen. The aerial symptoms are stunting, yellowing, marginal and tip drying of leaves, reduced tillering, stunting etc. At later stage of infection, the symptoms are poor plant stand, premature drying and lodging of tillers. In ginger these nematodes feed on tender roots, rhizomes and base of pseudostem. Visible galls or tumor like appearance can be observed in the root system. Aerial symptoms are appearance of patches in the form of stunted plants and yellowing leaves followed by drying or necrosis, reduced tillering and poor crop stand. The infected rhizomes show lesions and rough region on fingers, which predispose the rhizomes to infection by secondary pathogens. Interaction of *Meloidogyne incognita* and *Pythium aphanidermatum* causes severe rhizome rot and root rot in ginger.

Lesion nematodes, *Pratylenchus* spp.

Pratylenchus is a migratory endoparasitic nematode occurring in subtropical and warm temperate region of the country. It has a wide host range and causes extensive damage on root and rhizomes of turmeric, which decay when infected with other microorganism. It infects roots and rhizomes and moves inter and intra-cellularly inside the plants. It produces hydrolytic enzymes that degrade plant cell wall, causes accumulation of phenolic compound and associated activation of oxidative enzymes in plant cells. Consequently, the cells become brown, exhibiting apparent symptom of browning. The above ground symptoms are slight yellowing, which starts at tip of leaf in older leaves, that advances downward. The leaves then show marginal drying and the dried areas of leaves appear whitish, fold backward or downward and the newly emerging leaves appear wrinkled, and fissured with visible light white spots. The nematode lays eggs singly in roots cortex cavity or soil and all stages are infective. Reproduction is mainly by parthenogenesis and the optimum temperature is 29.5˚C.

Lesion nematodes have become a potential threat in turmeric growing areas. It causes dry rot or brown rot symptoms on rhizomes and severe yield loss in the field as well as in storage. The below-ground symptoms include discoloration and rotting of mature rhizomes. In advanced stages of infection, the rhizomes become deep red to brown in color, less turgid and wrinkled with dry rot symptoms. Fingers are severely affected than mother rhizomes and affected rhizomes shows internally necrotic patches with spongy texture. Water oozes out on pressing and with further advancement, they start rotting. The fingers are more severely affected than the mother rhizomes; internally the affected rhizomes show dark brown necrotic lesions. The nematode also acts as a predisposing factor, paving way for secondary infection with soil borne pathogens such as *Pythium* spp., *Fusarium* spp. etc.

Black pepper infected by *R. similis*   **Root knot nematode infected ginger field**

Symptoms of Lesion nematode infection on turmeric plant and rhizomes

In ginger too, lesion nematodes cause severe damage to roots and rhizomes. Several species are reported to infect ginger namely *P. coffeae, P. brachyurus, P. indicus, P. pratensis* and *P. zeae* causing ginger yellows. Infected rhizomes show water soaked regions on outer surface, appear like wrinkled and dried patches which become dark brown in advanced stage of infection. Later, rotting of rhizomes predisposes the plant to *P. aphanidermatum* infection which further aggravates the severity of infection.

Nematode management

i. ***Use of nematode-free planting materials***: In spices, plant parasitic nematodes are mostly disseminated through infected planting materials like rooted cuttings, seedlings or seed rhizomes. In nurseries only sterilized soil fortified with bio-agents like *Pochonia chlamydosporia* (@ 20 g /m^2) should be used as the potting mixture. In ginger and turmeric, healthy and nematode-free seed rhizomes should be collected from nematode-free areas by careful visual examination.

ii. ***Phytosanitation***: Infected field should be avoided for new planting. Select sites free from nematodes by prior sampling and screening for nematodes. Susceptible standards/shade trees are the main source for repeated attack by nematodes which can be avoided in black pepper/cardamom fields.

iii. ***Cultivation practices*****:** Deep summer ploughing in ginger and turmeric fields during April-May minimizes the soil population of nematodes. Soil solarization using transparent polythene sheets during summer season for 40-50 days can also drastically reduce nematode population in soil. In ginger, crop rotation with paddy, oil seeds - mustard, gingelly or lablab, tuber crops - taro and cassava can break the life cycle of nematodes. Allelopathic effect by sun hemp and marigold also reduces the nematode population.

iv. ***Organic amendments***: Application of organic cakes like neem oil cake @ 250g/plant for black pepper and cardamom twice during pre-monsoon (May-June) and post monsoon (Sep-Oct) months can minimize the nematode damage. In ginger/turmeric neem oil cake can be incorporated @1 t/ha at the time of sowing. Application of cattle compost of FYM @ 25-30 t/ha will increase beneficial microorganisms in ginger/turmeric fields.

v. ***Biological control:*** Sustainable nematode management can be achieved through biological control. Several bioagents are commercially available today for effective management of nematodes. *Pochonia chlamydosporia*, *Paecilomyces lilacinus* etc. are highly effective especially against root–knot nematodes. However, quality of biocontrol products should be ensured for desired results.

vi. ***Use of resistant varieties***: Resistant or tolerant verities are ideal option for avoiding yield losses due to nematodes. In spices we have few resistant varieties against root-knot nematodes like IISR Pournami, a black pepper selection, IISR Mahima, a ginger selection. IISR Pragati a short-duration turmeric variety which has some degree of tolerance to root-knot nematodes

Chemical control: Blanket application of nematicides is not advisable in any crop. However judicious use of nematicides like carbofuran (Banned in kerala), carbosulfan or new products like fluensulfone, fluopyram can be undertaken in nematode affected areas.

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NUTRIENT (N&K) REQUIREMENT AND METHOD OF APPLICATION TO ECT COCONUT NURSERY

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Introduction

Coconut nursery is not usually supplied with fertilizers on the assumption that there is sufficient stored food inside the seed nuts and that the intrinsic quality of the seed material measured in terms of the seedling growth characters may be vitiated by fertilizer application. Foale (1968) found that the contribution of nutrients from the endosperm to the growing seedling was reduced from the fourth month after germination there by necessitating fertilization of seedling vigour is to be maintained in the nursery. In India also application of NPK fertilizers in combination with Ca+Mg improved seedling vigour and quality as indicated by higher chlorophyll content and nutrient concentration in leaves (Nelliat *et al*.,1976).The possibility of selecting vigorous seedlings during early stages and the fertilizer requirement of nursery were also looked into. However, experimental findings on effectiveness of methods of manuring are very limited and hence this study was undertaken to work out on optimum fertilizer schedule and method of application for the ECT coconut seedlings in the nursery.

Methodology

Field experiments were conducted during December 2018 to March 2021 at Coconut Research Station, Veppankulam, Thanjavur to study the nutrient (N&K) requirement and method of application to East Coast Tall coconut nursery. The experiment was comprised of eight treatments with three replications laid out in Randomized Block Design. The treatments consist of soil application of four levels of N&K (40, 80, 120 and 160 kg/ha each) applied in three splits during 5th, 7th and 9th month after nut sowing and foliar application of N and K at three concentrations (1%, 2% and 3% each) applied during 6th, 7th, 8th and 9th month after nut sowing along with a absolute control. For all the treatments except control plot, P @ 80 kg/ha was applied as basal dose. The observation on seedlings growth characters *viz.*, plant height, collar girth, number of leaves, percentage of splitted leaves and root characters were recorded at 10th month after nut sowing.

Experimental result

Based on the two year data, soil application of NPK @ 160:80:160 kg/ ha, at fifth, seventh and ninth month after sowing recorded higher plant height (147.3cm), collar girth (14.5 cm), number of leaves per seedling (8.2) and percentage of seedlings with splitted leaves (14.1%). Likewise, the number of roots per seedling (13.4), root volume per seedling 97.5 cc), root dry weight per seedling (20.1g) and outturn of quality of seedling (92.2 %) were associated with soil application of NPK @ 160:80:160 kg/ha, at fifth, seventh and ninth month after sowing. Basal application of phosphorus at 80 kg/ha and foliar spray of N and K even at 3 per cent failed to exert significant results.

Economics

On cost economics even though the cost of cultivation was highest with soil application of NPK @ 160:80:160 kg/ha, at fifth, seventh and ninth month after sowing, the highest gross income and net income leads to higher B:C ratio (1.96) and thus makes this treatment a economically viable one.

Conclusion

Soil application of NPK @ 160:80:160 kg / ha, at fifth, seventh and ninth month after sowing for East Coast Tall coconut nursery was found to be best in terms of growth, root characters and economics.

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GENERAL OVERVIEW ON ROOT CROP HARVESTING EOUIPMENT'S

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Introduction

Root crops are the crops which grows the essential part below the soil surface i.e., potato, carrot, cassava, cocoyam, coleus, garlic, ginger, groundnut, onion, turmeric, and vetiver. Almost all root crops are having weaker shoot system thus it should be harvested by digging operation (Saimurugan *et al*., 2021). Hence, harvesting of these crops is a critical operation and demands digging of the soil which needs more power substantially as compared to the power required for other unit operations in the crop production. In traditional method of harvesting, cost of harvesting operation significantly very high and there are huge loss ranging from 30 – 40 per cent of the total produce due to damage caused during harvesting, handling, storage, transportation and processing of carrots (Rani *et al*., 2018 and Shirwal *et al*., 2014). Besides, the quantum of labour, manual harvesting involves considerable drudgery and human discomfort. Further, these crops required specially designed equipments to dig and separate them from the soil (Issa *et al*., 2020). The power requirement for digging of the soil is varies depending upon the type of the soil, depth of the crop and roots' density. Earlier, harvesting of these crops was done manually by digging the soil with the help of hand tools like spade and khurpi etc. Under traditional method of harvesting, the yields are low, cost of cultivation is high and there is huge losses ranging between 30 – 40% of the total produce due to damage caused during harvesting and handling (Srivastava, 2000). By practicing mechanical means of harvesting, labour requirement is found 60% less as compared to traditional method of manual harvesting with less crop damage (Sukhwinder, et al., 2007).

Design considerations

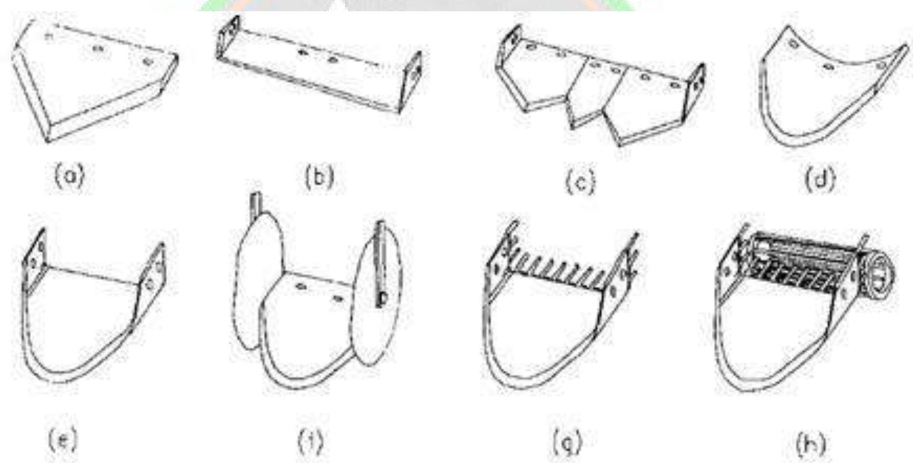
Root crop harvesting machines should be able to uproot the crops from below soil surface and bring them on the ground surface efficiently without any damage. In order to design and development of any root crop harvester, the researcher should consider some functional requirement of the digging equipment. The functional requirements are as fallows.

1. Width of the machine should be according to the roots spread in the soil (Issa et al 2020).
2. The equipment should be able to dig the whole roots present in the soil at an optimum forward speed of the prime mower.
3. The equipment should be able to operate in most of the types of the soils.
4. The machine should meet the agro-technique requirement (Hevko et al., 2016)
5. It should dig the roots at an optimum depth according to the crop depth.
6. It should elevate the root crop as well as soil and the separate the essential part from soil.
7. Functional performance of the machine such as durability, consistency during operation, conveyor operation and machine manoeuvrability should be good.
8. Amount of power required for the digging equipment for operating in various kinds of the soils.
9. It will be better, if the equipment will be tractor-mounted type and fabricated from easily available materials.
10. It should be suitable for different row spacing of the root crops
11. There should be minimum damage to the root crop
12. It should be suitable to the tractors which are majorly available in the local market.

Generally, the root crop digging equipment will have soil penetration tool, soil-root conveying system, soil separation mechanism, main frame and power transmission system. Details regarding all these components are mentioned below.

Soil penetration tool or digging blade

Generally, the soil can be considered as an elastic – plastic continuum in nature. The function of excavating shovel or soil penetration tool is to dig the soil during the root crop digging operation. Soil penetration tool of any digging equipment would be required to face variety of forces during soil excavation process (Zhao et al., 2015). Type and quantum of forces acting on tool is depending upon the depth of digging operation, moisture content of the soil and type of soils. For a long time, many researchers have made great efforts on design and development of digging blades and achieved significant results in terms of different kinds of designs. There are some traditional digging blades which are almost same in the country as well as abroad. Fig. 1 shows the different kinds of digging blades. Generally, in all potato diggers triangular flat shovel (Fig. 1.a) is being used and it is characterised by simple in structure, easy manufacturing and no power transmission is required and but it will make soil obstruct and increase the resistance. In case of strip plane shovel (Fig. 1 b) is suitable only for soils which are having less viscosity and adhesion force. It demands more draft power to penetrate into the soils. Multi piece shovel is improvised version of the triangular shovel, which is highly efficient to penetrate into the soil. Further remaining shovels i.e. Fig d – h will have option to cut the soil vertically but the problem of resistance created by soil to the shovel remain same.



(a) Triangular flat shovel (b) strip plane shovel (c) multi piece shovel (d) concave shovel a concave groove shovel (f) with rounded concave coulter blade (g) with separate grates trough concave shovel (h) with imitation squirrel – cage plug with longitudinal groove concave shovel with earth rolls.

Fig. 1. Forms of traditional diggers (Zhao et al., 2015)

The resistance of excavation shovel is influenced by the width, depth, rake angle and volume of soil need to be handled during the digging operation. Rake angle is inclination of soil penetration tool, which will affect the various parameters like depth of operation, digging efficiency, presentation of damage of roots and amount of force required to pull the digger. Generally the rake angle of soil penetration tool will be found between 15 to 25 degrees. Digging efficiency and draft of the digger is directly proportional to the rake angle **(Narendra and Shrivastava 2021)**. Further, the regime of soil failure and soil-acting forces are different for different shape blades, also the tool geometry factors like macro shape, micro shape and surface roughness influenced draft in a significant manner. The degree of confinement of the soil as induced and controlled by the geometry of the cut substantially affected the draft force of the tool. Generally in the most of the blades, high carbon steel (EN45) being used, which provides high wear resistance and is less ductile.

Soil parameters affecting digging operation

In digging of root crops, soil related factors plays significant role in soil failure during harvesting operation. For example, the machine parameters like digging depth, digging width, digging efficiency, crop damage percentage is depending up on the soil physical parameters mentioned below.

1. Soil strength: - It indicates the capacity of soil resistance or support to exert force of specific soil during digging operation. The strength of soils is varied in different kinds of soils. It depending up on the soil texture.
2. Soil moisture: - it is one of the important factor affecting the soil strength. If the soil having too much moisture, it will be easy to penetrate into the soil. If the soil is too much hard and dry. Then it will be too much difficult to penetrate into the soil due to more resistance of the soil.
3. Soil cohesion: - it indicates the bond between the soil particles, this is due to interaction of water particle in between the soil. Cohesive force plays major role in soil strength.
4. Soil adhesion: - this property appears between the soil and other objects, when it will be compressed by other material. The soil moisture and clay content of the soil causes the adhesion force between the soil and other objects.
5. Soil bulk density; - It indicates the heaviness of the soil particles. Digging operation in heavy soils is very difficult, because digging operation deals with handling of huge amount of soil. Hence more power is required for operation in heavy soils.
6. Soil porosity: - It indicates the amount of space occupied by air in the soil. If the porosity of the soil is high, then the penetration into that soil is very easy. Thus digging operation becomes easy.

Concept of Vibratory tools

Ultimate goal of any root crop digging equipment is to dig the soil and bring them on the ground surface without any damage. But the challenging task in digging operation is that the penetration of digging tool into the soil at a depth where the root crop reached in the soil and with minimum force of penetration. During the digging operation, the digging tools are need to face the compressive stresses which results in shearing failure of the soils. Practically all tools consist of some device for applying pressure to the soil, often by means of inclined planes or wedges, or their combinations. Since, the soil is strongest in compression, hence, the digging tool requires excessive energy to disturb the soil condition.

In the year 1963, Hendrick and Buchele brought a concept of providing vibratory tool for tillage equipment to reduce the draft significantly. This vibratory tool has been mounted in a tillage equipment keeping the following three points in mind, a. the maximum displacement of the soil is in the region of the shear plane, b. maximum acceleration of the soil mass occurred at the cutting edge of the tool, and c. mounting the standard rigidly minimized the tool mass to be actuated. Thus vibratory and rotary tillage tools develop smaller soil clods than do non-vibratory ones. As a result, the draft of the tillage tool is reduced significantly. In same way, in root crop harvesters, vibratory tool reduces the amount of force required for shovels to penetrate in to the compact soils. Due to these vibratory tools, one can able to achieve 50% draft reduction with vibratory frequency of 12 Hz (Hongguang *et al.*, (2017).

Development of soil separation mechanisms

Separation of root crops from extraneous matter is a complex problem because of the extremely variable nature of the tare material and the widely assorted sizes and shapes of the roots crops. Constantly changing soil conditions, temperatures, and crop characteristics produce problems requiring alertness and taken judgement on the part of the harvester operator. Generally, to improve the soil separation from the tubers, some rod conveyors or chain conveyors are used in most of the root crop harvesters. The slope and speed of the conveyor of the soil separation unit has significant effect on the performance of the soil separation unit. Further, by using some intensifiers and shakers like, elliptical, cam, agitators and screws, soil separation process can be improved. The soil separation will be achieved due to intensive tossing of the material but the damage of the potato will be increased. Therefore, to improve the soil separation without damage to the tubers, transverse agitators are most suitable (Kostenko *et al.*, 2020). Optimum slope to achieve maximum soil separation from tuber is 15 degrees for all root crops (Hevko et al., 2016). The separation index increased with the increase both in speed ratio and length of unit.

In addition, the harvesting efficiency of the digger is depending upon the soil parameters like moisture content of the soil, soil texture and compactness of the soil at the time of harvesting. Overall, nearly the cost of harvesting of root crops with the help of mechanical harvester can be reduced by 50 to 70 % as compared to the manual method of harvesting.

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NEW INTERVENTION ON PABDA CUM IMC POLYCULTURE IN NORTH TRIPURA DISTRICT TO INCREASE THE FISH PRODUCTIVITY AND PROFITABILITY

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Introduction

Pabda is a species of catfish which is considered as a high value fish in the markets of Tripura as well as in the North Eastern Region of the country. It's a very delicious fish and was declared as "State Fish of Tripura". Pabda fish is a freshwater fish species. It is very tasty and has high nutrition value. So it has a great demand and high value in the market. Pabda fishes can be found mainly in the pond, swamp, paddy field etc. Pabda fish culture is considered as high value fish culture and the profit obtained from this type of fish culture is also higher than normal fish culture. The farmers of North Tripura district are mainly associated with culture of Indian Major Carps, exotic carps and few other minor carps etc. in traditional ways under normal fish culture activities. The earnings from this type of traditional fish culture practices are less compared to culture of high value commercial fish species. Keeping this in mind, polyculture of Pabda with Indian major carps appeared to be an innovative as well as high earning source of fish culture practice in this district.

In current fish culture set up three Indian carps Catla catla, Labeo rohita, Cirrhinus mrigala and two Chinese carps, silver and grass carp are considered the best combination (Rahman *et al*., 2006).It is a well-known fact that improvements in efficiency are more cost effective than introducing a new technology (intensive fish culture), the farmers are not efficient in the use of the existing technology (Krishnan, M. & P.S. Birthal 2002)

Intervention

India offers a huge potential for freshwater aquaculture development as it is blessed with extensive river and canal system of about 195.210 km, consisting of 14 major rivers, 44 medium rivers and numerous small rivers and streams. In addition, pond and tank resources are estimated at 2.36 mha (FAO. 2014, Handbook of Fisheries and Aquaculture, 2014).

An innovative approach was undertaken by Krishi Vigyan Kendra North Tripura for development of polyculture practice of Pabda with Indian major carps among the special interested groups of farmers in different places of North Tripura district. Under this activity at first beneficiaries were selected based on their interest and three numbers of training programmes were conducted by KVK among the interested farmers.

Polyculture of Pabda with Indian major carps was undertaken at South Hurua area of Dharmanagar in a total area of 1.92 ha. Total 6 nos. beneficiaries each having 0.32 ha of pond area took the initiative for culture of Pabda for the first time and they were trained properly about the culture method and management practices as there was no established method of Pabda culture in the district. Inputs given to the farmers include 500 nos. of pabda fingerling to each farmer along with 2000 nos. IMC fingerling and also artificial fish feed (120 kg each). The title of the trial was "Growth Performance of Pabda (*Ompok bimaculatus*) in polyculture system".

Technology: Growth Performance of Pabda (*Ompok bimaculatus*) in polyculture system.

Pic: Pabda fingerling distribution in Chandrapur GP.

(Details- Carp seed (IMC)- Rahu, Catla, Mrigal were stocked @10,000/ha, Pabda @ 3000/ha Culture period 7-8 months, feeding with floating pelleted feed and also natural fish food items in the pond, Initially feeding i.e. finely powdered (rice bran + MOC) @ 3-5 % OF Body wt upto 2 months, Floating pellet feed from 3rd months onwards @ 2-3 % body wt.**)**


Pic: IMC fingerling distribution in Chandrapur GP.

Result: (In trial ponds stocked with IMC seed and Pabda seed)

a) Fish yield (IMC): 406 kg/0.16ha
b) Fish yield (Pabda): 28 kg/unit
c) Net return (Rs/Unit): 49,900 /-per 0.16 ha
d) B:C Ratio (GR/GC): 3.16

Result: (In control ponds stocked only with IMC seed)

a) Fish yield (IMC): 210 kg/0.16ha
b) Fish yield (Pabda): Nil
c) Net return (Rs/Unit): 18,500 /-per 0.16 ha
d) B:C Ratio (GR/GC): 2.32

Pic: Trial on Growth Performance of Pabda (*Ompok bimaculatus*) in polyculture system.

Pic: Trial on Growth Performance of Pabda (*Ompok bimaculatus*) in polyculture system.

Pic: Harvesting of IMC & Pabda from trial unit.

Impact of the Technology

The inputs like Pabda fingerling, Pelleted fish feed and fish fingerling were distributed free of cost to the farmer under the trial. Cost of manuring was barred by the farmers themselves. After 10 months the fishes were harvested and sold to the nearby Dharmanagar market. The demand of Pabda fish was very high, in the Dharmanagar market fetching as high as Rs. 600.00 per Kg. Carps fishes were sold @ Rs. 150.00 - 200.00 per Kg. They received average net income of around Rs. 49,900/ 0.16 ha which was much higher compared to normal fish culture practice which was around Rs. 18,500/ 0.16 ha.

After the great experience with the Polyculture of Pabda with IMC practice under the supervision of KVK North Tripura, those farmers also started sharing all of their experiences and related information about the benefit of Polyculture of Pabda with IMC with their neighbours & also other farmers of North Tripura.

Impact and Horizontal expansion

Similarly polyculture of Pabda and IMC was started in Chandrapur GP, West Tilthoi GP and Uptakhali GP in the next financial years under Panisagar and Dharmanagar Sub division under North Tripura District among the different interested farmer's groups which showed great results and adoption among the rural farmers of the District.

Pic: Horizontal expansion of Polyculture of Pabda with IMC in Chandrapur GP.

Pic: Horizontal expansion of Polyculture of Pabda with IMC in Chandrapur GP.

Pic: Horizontal expansion of Polyculture of Pabda with IMC in West Tilthoi GP.

Conclusion:

This in turn improved their livelihood and socio economic status like other parts of India. This type of fish culture technology can also be replicated in other parts of Tripura state to obtain better profit than normal fish culture practice. Of late more and more farmers are coming frequently in the KVK North Tripura office for taking training and gathering knowledge about the benefits of Polyculture of Pabda with IMC. This shows the wide and horizontal expansion of this culture technology among the rural fisher folk of this District. Till now more than 100 farmers have adopted culture of Pabda along with IMC under the supervision of KVK North Tripura.

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CARDAMOM – THE QUEEN OF SPICES

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Introduction

The small cardamom (*Elettaria cardamomum* Maton) popularly known as 'Queen of Spices' is a tall perennial herbaceous plant that belongs to the family *Zingiberaceae*. Cardamom is indigenous to Western Ghats in south India, the hilly region of the country in Kerala, Karnataka and Tamilnadu are having more favourable agro-climatic conditions for cultivation of cardamom. Cardamom is shade loving crop and suitable for cultivation as inter or mixed cropping system in arecanut and coffee plantations. Cardamom is a high valued crop and good income generating crop. There is a lot of export demand because of high quality and also maximum internal consumption need expansion of area and more production.

Botany

Cardamom is a tall growing, cross-pollinated, herbaceous perennial, with branched sub terranean rhizomes. The real stem is the rhizome, which is subterranean in habit. Cardamom is a shallow-rooted plant.

Climate: The crop thrives well in evergreen tropical forests at an altitude of 600 m to 1500 m above MSL. Cardamom is found to grow well even in areas where the annual rainfall ranges from 150-400 cm, provided the rainfall is well distributed. It grows well in a temperature range of 10° to 35°C.

Soil

Well-drained soils rich in organic matter, forest loams rich in phosphorus and potassium and deep light-textured lateritic soils with a pH range of 4.6 to 6.5 and rich in humus content are good for the crop. It is mostly grown as a pure crop in the lower portion of undulating valleys.

Varieties

Based on the size of the fruit, two varieties are broadly recognized viz., *Elettaria cardamomum* var. major consisting of wild indigenous types and var. minor comprising the cultivated types viz., Mysore, Malabar and Vazhukka (natural hybrid between Mysore and Malabar). These types are identified mainly based on the nature of panicle and shape and size of fruits as follows:

Particulars	**Malabar type**	**Mysore type**	**Vazhukka**
Plant stature	Medium sized	robust	Robust
Panicle	Prostrate	Erect	Semi-erect
Capsule	Round to oblong	Bold, elongated	Round to oblong
Adaptability	Lower altitudes (600 - 900 m)	Higher altitudes (900 – 1200m MSL) in Kerala)	Wide range

Malabar Mysore vazhukka

Recently a number of improved cultivars have been released for cultivation.

Sl. No.	**Name**	**Cultivar**	**Parentage**	**Brief description**
IISR, Cardamom Research Centre, Appangala				
1.	IISR, Avinash	Malabar	Selection from open poliinated progeny of CCS-1	High yielding variety with extended flowering period. Dark green capsule. Suitable for planting in valleys. Recommended for rhizome rot and leaf blight prone areas.

				Essential oil - 6.70 % Average yield - 847 kg /ha Dry recovery - 20.80 %
2.	IISR Vijetha 1	Malabar	A selection from field resistant plants for katte	Virus resistant selection with bold capsules and good appearance. Suitable for katte prone areas. Adapted to moderate rainfall and high shade areas. Essential oil - 7.90 % Average yield - 643 kg /ha Dry recovery - 22.0 %
3.	IISR Kodagu Suvasini	Malabar	Selection from open pollinated progeny of CL-37 from RRS, Mudigree	Early maturing variety with long panicle, suitable for high density planting. Suitable for all cardamom growing tracts of Karnataka and Wynad of Kerala. Tolerant to rhizome rot, thrips, shoot/ panicle/ capsule borer. Essential oil - 8.70 % Average yield - 745 kg /ha Dry recovery - 22.00 %
ICRI, Myladumpara, Idukki				
4.	ICRI 1	Malabar	Selection from Chakkupalam collection, a Malabar type.	An early maturing, profusely flowering variety with medium sized panicle, globose extra bold dark green coloured capsules. Essential oil - 8.30 % Average yield - 656 kg /ha Dry recovery - 22.90 %
5.	ICRI 2	Mysore	Clonal selection from germplasm collection	Tolerant to azhukal disease. Performs well under irrigated conditions. It has medium long panicles with oblong bold and parrot green capsules. Suitable for higher altitude. Vandanmedu and Nelliyampathy of Kerala and Anamalai, Meghamalai of Tamil Nadu Essential oil - 9.0 % Average yield - 766 kg /ha Dry recovery - 22.50 %
6.	ICRI 3	Malabar	Selection from Malabar type	Early maturing type with non pubescent leaves, oblong bold and parrot green capsules. It is tolerant to rhizome rot disease. Suitable for hill zones of Karnataka. Essential oil - 6.60 % Average yield - 599 kg /ha Dry recovery - 22.0 %

7.	ICRI 4	Malabar	Clonal selection from Vadagaraparai area of lower Pulneys, a Malabar type	Early maturing type with medium sized panicles and globose panicles. Relatively tolerant to rhizome rot and capsule borer. Suitable for low rainfall regions. Adapted to Lower Pulney hills. Essential oil - 6.40 % Average yield - 961 kg /ha Dry recovery - 22.0 %
8.	ICRI 5	Malabar	MCC 260 X MCC 49	Early maturing, moderately drought tolerant variety giving high yield under intensive management. Suitable for Kerala and parts of tamil Nadu. Essential oil - 7.13 % Average yield - 1543 kg /ha Dry recovery - 23.15 %
Cardamom Research Station, Pampadumpara, KAU				
9.	PV-1	Malabar	A selection from Walayar collection	Early maturing variety with elongated capsules. Suitable for all cardamom growing tracts of Karnataka and parts of Tamil Nadu Essential oil - 6.80 % Dry recovery - 20.00 % Average yield - 500 kg /ha
10.	PV-2	Malabar	A selection from open pollinated seedlings of PV1	Early maturing variety with deep green, long bold capsules. It is a high yielder which is field tolerant to stem borer and thrips. Suitable for elevation range of 1000 to 1200 meters above MSL Essential oil - 10.45 % Dry recovery - 23.80 % Average yield - 982 kg /ha
University of Horticultural Science, RRS, Mudigree				
11.	Mudigree 1	Malabar	Clonal selection from Malabar type	Erect and compact plant with short panicle and pale green, bold oval capsule. Suitable for high density planting. Moderately tolerant to thrips, hairy caterpillar and white grubs. Suitable for traditional cardamom growing Malanad areas of Karnataka. Essential oil - 8 % Dry recovery - 20.00 % Average yield - 275kg /ha
12.	Mudigree 2	Malabar	Clonal selection from open	Early maturing, suitable for high density planting with round/oval bold capsules. Suitable for cardamom growing tracts of

			pollination of Malabar type	Karnataka Essential oil - 8 % Dry recovery - 20.00 % Average yield - 475 kg /ha
13.	Mudigree 3	Malabar	Clonal selection from clone 692	Capsules are oval/oblong in shape which is light green, turning pale yellow on ripening. Suitable for cardamom growing tracts of Karnataka
14.	Coorg cardamom Selection-1 (CCS-1)	Malabar	Open pollinated seedling of clone	Released by NRCS, Cardamom Research Centre, Appangala 37. Dry recovery 22%, Essential oil content 8.7% Yield 408
	Farmer's variety			
15.	Njallani Green Gold	Vazhukka type	Clonal selection	High yielding clonal selection by a cardamom grower in Idukki district. Capsule bold, over 70% of the cured cardamom above 7mm.Reported to be high quality. Currently the highest yielding cultivar. Yield up to 5000 kg/ha has been recorded.

B. PROPAGATION

Cardamom can be propagated by seeds and vegetative means. Seedling population is variable because cardamom is a cross pollinated crop. Hence, vegetative propagation is usually adopted in case of elite clones. Vegetative propagation can be done through rhizome bits (suckers)

(i) Propagation through seeds

I. Primary nursery

a. Seed selection and Preparation of seeds

Fully ripened bold capsules from high yielding, disease-free mother clumps are collected from second and third harvests during the month of September. One kg fresh capsules comprising of about 500-800 fruits is sufficient to produce 3000-5000 seedlings. The seeds are extracted by gently pressing the capsules and then washed 3-4 times in cold water to remove the mucilage adhering to the seeds. The washed seeds are drained, mixed with wood ash and dried under shade. To ensure early and uniform germination, seeds should be sown immediately after extraction, preferably within 15 days since viability of the seed is lost during storage. The ideal season for sowing is September in Karnataka and November-January in Kerala and Tamil Nadu.

b. Pre sowing treatment of seeds

Acid scarification with 25% nitric acid increases the germination percentage. For this, wrap the extracted seeds in nylon net, tie it loosely and then immerse in 25% nitric acid for 10 minutes. After treatment, the seeds are removed and washed repeatedly in cold water to remove traces of acid.

c. Nursery site

The nursery site is selected in open, well-drained areas, near a water source. Prepare the area by removing existing vegetation, stumps, stubbles and stones and dig to a depth of 30 cm. In the prepared area, beds of size 6 m x 1 m x 0.2 m are made and a thin layer of humus rich forest soil is uniformly spread over the beds.

d. Seed rate and sowing

Sow the seeds in rows spaced at 10 cm and 1-2 cm apart within the row. The seed rate for 6 m x 1 m sized bed is 30-50 g. After sowing, the beds are covered with a thin layer of sand and mulched with grass or paddy straw to a thickness of 2 cm over which tree twigs are laid. Water the beds regularly to maintain sufficient moisture and to promote germination. Germination commences in about 20-25 days and may continue for a month or two. Once sprouting is observed, remove existing mulch and maintain thin mulch material between the rows. Protect the seedlings by providing overhead shade. Transplant the seedlings at 3-4 leaf stage to the secondary nursery.

e. Mulching

Mulching of seed beds influences germination. Paddy straw mulch is best suited for the primary nursery as it enhances the germination percentage.

II. Secondary nursery

Seedlings are raised in the secondary nursery by two methods.

a. Bed nursery

Nursery beds are prepared in same manner as for primary nursery. Shade is to be provided by erecting overhead pandal. Seedlings are transplanted when they are 4-6 months old (4 to 5 leaf stage) at a distance of 20cm x20cm. Beds are mulched and watered regularly. Weeding, manuring and plant protection practices have to be attended whenever needed. One month before transplanting, the overhead shade is removed to enhance tillering. In Kerala 18-22 months old seedlings are used. Two year old seedlings are the best for getting more tillers and higher yields.

b. Polybag nursery

Polythene bags of size 20 cm × 20 cm and 100 gauge thickness are filled with potting mixture consisting of forest top soil, cow dung and sand (ratio 3:1:1). Provide sufficient holes at the base of polybags to ensure good drainage. Seedlings at 3-4 leaf stages are transplanted into each bag (one seedling/bag). Seedlings raised in the polybags have a uniform growth and nursery period could be reduced by 5-6 months.

In Karnataka, ten months old seedlings are used for planting in the main field while in Kerala and Tamil Nadu, 18 months old seedlings are commonly used.

III. Vegetative propagation:

Clonal propagation is advantageous in places where "Katte" disease is not a menace. Also plants raised from rhizomes come to bear early compared to seedlings. Cardamom is propagated vegetatively by division of rhizomes. A portion of the rhizome with one old and one young shoot consists of a planting unit.

Rapid clonal multiplication technique

Suckers are collected from high yielding plants and planted at a spacing of 1.8m x 0.6m, thus accommodating approximately 6800 plants/ha of clonal nursery area. Overhead shade is provided and nursery is irrigated. Fertilizers at the rate of 48: 48: 96 kg NPK /plant is given in two splits. After 12 months of planting, each planting unit produces on average 32-42 suckers. In an area of 1ha clonal nursery 1 to 1.4 lakhs planting units can be produced after one year. A crop of 190g/plant of dry cardamom (1759kg/ha) also could be harvested within just 19 months of planting. On an average, 15- 20 good quality planting units could be produced from a mother clump within ten months of planting.

Cultivation

Selection of land, preparation and system of cultivation

The land selected for cultivation of cardamom should be cleared and excess shade trees or branches should be thinned out. The land should be prepared by adopting adequate soil conservation techniques. Normally gentle slope lands or valleys are preferred for cultivation of the crop. Terraces should be formed across the slope at suitable planting distances. Planting distance should be more in high rainfall areas or irrigated condition and less in low rainfall areas. Spacing depends on soil fertility, type of cultivars and terrain. Spacing adopted is more in Kerala while in Karnataka, closer spacing is followed. Spacing of 1.8 m x 1.8 m or 2 m x 2 m is recommended for Malabar variety. 3 m x 3 m for Mysore and Vazhukka. However, in fields of low fertility, plant density can go up to 1600/ha for Mysore and Vazhukka and up to 3000/ha for Malabar. For Karnataka, a general spacing of 1.8 m x 1.8 m is suggested. A spacing of 1.8 m x 1.8 m (3025 plants/ha) and 2.7 m x 2.7 m (1371 plants/ha) is recommended in Malabar and Mysore types respectively in Tamil Nadu. Pits of size 45 cm x 45 cm x 30 cm are dug during April-May, filled with a mixture of surface soil and compost or well-rotten farm yard manure + 100 of rockphosphate. This has to be done two months in advance of planting of seedling for better establishment and good growth. Best season for planting is with commencement of South West monsoon before heavy rains. Cloudy days with light drizzles would be ideal for planting and result in early and maximum percentage of establishment. Avoid deep planting. A small mound may be formed inside pit to cover the rhizome and immediately after planting mulching should be done. Plants should be supported by stakes. In Karnataka 10-12 months old and 18-24 months old seedlings in Kerala are used for planting in the field.

Shade management

Cardamom is a pseophyte, it requires filtered light of 50-60 percent for better growth and yield. Shade management is an important operation in cardamom plantation. Shade trees having distributed branching pattern and small leaves are ideal for cardamom.

Some of the common shade trees in cardamom plantations are Balangi ***(Artocarpus fraxinifolius),*** Jack fruit (*Artocarpus heterophyllus* Lamk), Red cedar ***(Cedrella toona* Roxb*)***, Karimaram ***(Diospyros ebenum* Koenig*)*** and Elangi (***Mimusops elangi).*** The temporary shade trees like ***Erythrina lithosperma*** and ***E. indica*** are most unsuitable as they compete for nutrients and soil moisture.

Manures and Fertilizers

Fertilizer dose of 75:75:150 kg NPK/ha (half the dose for one year old plant) in two split doses is recommended under irrigated condition for high yielding plantations and above. 30:60:30 kg/ha for gardens under rainfed conditions Organic manures like compost or cattle manure may be given @ 5kg/clump. Neem oil may also be applied @ one kg per clump.

Liming

Cardamom is cultivated in heavy rain fall areas of hilly region, top soil along with nutrients or eroded as a result soils are becoming acidic. Before application of fertilizers soil ph as to be corrected by adding line based on the soil test results. However, every two years once 2 to 3 tonnes of lime per hecters is recommended and this as to be applied during April- May. Agricultural line and dolomite line are commonly used liming materials to correct the soil acidity.

Irrigation

Cardamom is sensitive to moisture stress and needs irrigation during summer. Irrigation at an interval of 10-15 days from December till commencement of monsoon is required. Irrigation during peak dry months (February to April) ensures increased yield. This is the period when development of young tillers and elongation of panicle take place. Water stress during this period of growth result in reduced yield.

Use of growth regulators

Exogenous application of NAA (40 ppm) or 2,4-D (4 ppm) increased plant height and panicle production. Similarly, spraying of NAA (25 ppm) twice (June and July) reduced fruit drop and increased fruit set. Application of ethrel (250 ppm) under high light intensity (15 K lux) doubled sucker production.

Pollination

Pollination in cardamom is entomophilous mainly by two species of honey bees viz. *Apis cerana* and Apis dorsata. Honey bees contribute over 90% pollination, lack of pollination causes fruit drop and fruit set in cardamom.

Weeding

Two to three weedings are required in a year depending on the weed growth. First weeding may be done in May-June before the fertilizers of application. Second weeding is done in August-September before the post monsoon application of fertilizers. It is very important to carry out the third round of weeding in November-December soon after the North-East monsoon is over for avoiding the competition of weeds for moisture and nutrients.

Mulching

It is an important cultural practice in cardamom. Fallen leaves of the shade trees are utilized for mulching. Sufficient mulch should be applied during November- December to reduce the ill effects of drough which prevail;ls 4 to 5 months during summer.

Exposing of panicles

From first week of June onwards exposed panicles by lifting them above the layer of mulch to facilitate the visiting of bees for pollination. This operation has to be followed 2 to 3 times in a cropping period.

Earthing up operation

After the monsoon is over a thin layer of top soil is earthen up to the base of the clump covering upto the collar region by scrapping between the rows or obtaining the soil from the trenches or check pits, which encourages the new growth and sucker production.

Trashing

Trashing consists of removing old and drying shoots of the plant once in a year with the onset of monsoon under rainfed conditions and 2-3 time in high density plantations provided with irrigation facilities Trashing from November onwards may be avoided due to the ensuing dry season.

Harvesting and processing

Cardamom plants start bearing fruits (capsules) from 2-3 years after planting and satisfactory yield is obtained from 5th year. It takes 110 days from flowering to fruit maturity. Harvesting season is in August-December; peak h arvest is during October-November. Capsules are harvested at an interval of 15-20 days at Karnataka and 30 days in Kerala and harvesting will be completed in seven-eight rounds. Fruits that are just ripened or physiologically mature (at the black seeded stage) are picked by experienced workers. If capsules are immature, they will have a wrinkled appearance on curing and if they are fully ripe they will split on curing and will develop an yellow colour. Essential oil content will be more at physiologically mature stage and dry recovery more at ripened stage. At physiologically mature stage, recovery is 24 %.

Two types of pickings are adopted - light picking and hard picking. In light picking, only mature capsules are harvested whereas in hard picking semi-mature crop is also removed. Choice depend on availability of labour. Cardamom harvesting is mainly done by women labourers. The average yield of dry capsules is ranged between 200-500 kg/ha.

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CROP DIVERSIFICATION FOR CLIMATE CHANGE AND SUSTAINABILITY

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Introduction

Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to lessen risk. Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. The crop shift (diversification) also takes place due to governmental policies and thrust on some crops over a given time, for example creation of the Technology Mission on Oilseeds (TMO) to give thrust on oilseeds production as a national need for the country's requirement for less dependency on imports. Crop diversification as a key factor in reducing risk and means of coping with an uncertain climate. The aim of crop diversification that reduce current and future climate related risk. Market infrastructure development and certain other price related supports also induce crop shift. Often low volume high-value crops like spices also aid in crop diversification. Higher profitability and also the resilience/stability in production also induce crop diversification. Crop diversification and also the growing of large number of crops are practiced in rainfed lands to reduce the risk factor of crop failures due to drought or less rains. Crop substitution and shift are also taking place in the areas with distinct soil problems.

Concept of Crop Diversification

- A shift of a crop or cropping system to another crop or cropping system.
- Use of resources in best possible way by changing and modifying the degree trend and time option of a crop or cropping activities.

- A shift from less profitable and sustainable crop or cropping system to more profitable and sustainable crop or cropping system

PRESENT SCANARIO

- Regional imbalance in production and productivity
- Climate change, pollution ,salinity, alkalinity
- Depleted water table in greenbelt
- Untapped water resources in dry land
- Rising cost of input hence, cost of production
- Reduction in factor productivity

STRENGTH

- Food grain production raise from 50.8 to 212.06 MT
- Close to one fourth GDP contributed by agriculture
- Largest producer of milk and tea
- Second largest producer of Rice, Wheat, Vegetable, Tobaco
- Open access to international market

NEED OF CROP DIVERSIFICATION

- For raising farm income
- Sustainable production and income
- Reduce the risk of climate change
- Promotion of export
- Employment generation
- Poverty alleviation
- Judicious use of land and water resources
- Reduction in environmental pollution

OBJECTIVE OF CROP DIVERSIFICATION

- Ensuring Food Security
- Adapting to Climate Change
- Safeguarding Biodiversity
- Reducing Poverty
- Ensuring Sustainable Agriculture

THUS, THE NECESSITY FOR CROP DIVERSIFICATION ARISES ON ACCOUNT OF THE NEED FOR-

- Reducing the risk associated with yield ,market and prices
- Arresting the degradation of natural resources and environment
- Attaining the national goal like self-reliance in critical crop products , earing foreign exchange and employment generation.

DETERMINANTS OF CROP DIVERSIFICATION

- Number of factor governsnature and speed of crop diversification
- Resources endowment
- Agro climatic condition
- soil
- Labour
- Facility of irrigation
- Technological factors
- House hold factor
- Institutional and infrastructure factors
- Price factors

PRIORITIES FOR CROP DIVERSIFICATION IN INDIA

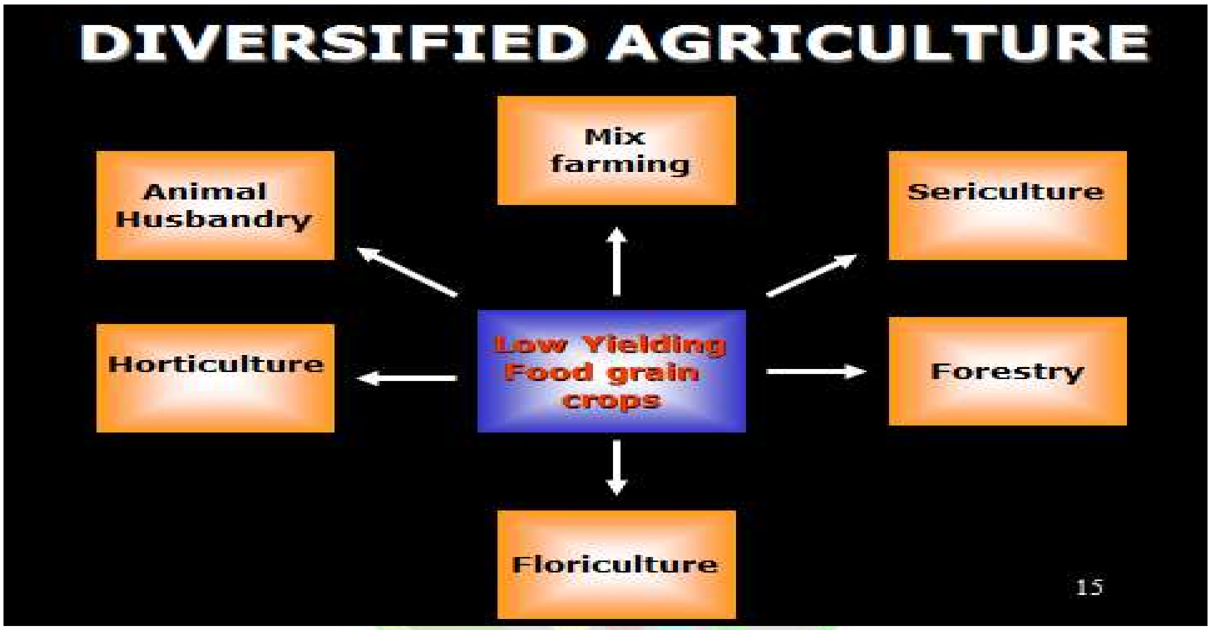
- Changing of resources use efficiency parameter
- Crop rotation effect
- Incorporation of crop and technologies
- Research on actual farm environment through farmer participatory mode
- Assurance against the risk to farmer under changing weather and sharp fluctuation in prices
- National issues like nutritional and food security.

REQUIRED STEPS FOR CROP DIVERSIFICATION.

- Delineate area: Scientific database priorities and target the area
- Choice of alternative crops and technology
- Priority Input /credit supply for alternative crops
- Share the risk of new system
- Market support –Rural uplinking.

OVERALL STRATEGIES FOR CROP DIVERSIFICATION

- Diversion of high water requiring crops to low water intensive crop
- Diversion of cotton to pulses oilseeds and maize in light textured and shallow soil
- Replacement of low yielding low value coarse cereal to high yielding to high value crops like pulses
- Intercropping and mixed cropping be promoted in dry area
- Shift high risk crop to short duration pulses and drought resistant oilseed crops



RESEARCH ACTIVITIES

- It is always desirable change the crops and cropping system in certain years.
- The choice of crop or cropping system depending upon price ,soil fertility and pest bulid up will be desirable.
- Synthesize or deside the most suitable system on considering productivity.
- Choice of suitable variety is very important to fit in the system with high productivity.
- Under the diversified intensive system of cropping, contigent planning also important.
- Therefore, suitable adjustment should to be made as per emerging need and prospects.

CONSTRAINTS IN CROP DIVERSIFICATION

- Over 117 m.ha (63 percent) of the cropped area in the country is completely dependent on rainfall.
- Sub-optimal and over-use of resources.

- Inadequate supply of seeds and plants of improved cultivars.
- Fragmentation of land holding less favoring modernization of agriculture.
- Poor basic infrastructure like roads, power, transport, communication etc.
- Inadequate post – harvest technologies.
- Very weak Agro-based industries.
- Week research-Extension-farmer linkage.
- Decreased investment in agriculture sector over the years.

GOVERNMENT POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

Considering the importance of crop diversification in the overall developmental strategy in Indian agriculture, the government of India has taken several initiatives for agricultural development in general and crop diversification in particular. These initiatives are as follows:

i) Launching a Technology Mission for the Integrated Development of Horticulture in the Northeastern Region: The programme will establish effective linkages between research, production, extension, post-harvest management, processing, marketing and exports and bring about a rapid development of agriculture in the region.

ii) Implementing National Agriculture Insurance Scheme: The scheme will cover food crops and oilseeds and annual commercial and horticulture crops. Small and marginal farmers are eligible for 50 percent subsidy under the Scheme.

iii) Operationalizing Technology Mission on Cotton: The Technology Mission will have separate Mini-Missions on technology generation, product support and extension, market infrastructure and modernization of ginning and pressing units.

iv)Provision of Capital Subsidy of 25 percent for construction/modernization/expansion of cold storages and storages for horticultural produce.

v) Creation of Watershed Development Fund: At the National level for the development of Rainfed lands.

vi) Infrastructure Support for Horticultural Development with emphasis on Post-harvest Management.

vii) Strengthening Agricultural Marketing: Greater attention to be paid for development of a comprehensive, efficient and responsive marketing system for domestic marketing as well as exports by ensuring proper quality control and standardization.

viii) Seed Crop Insurance: A pilot scheme on Seed Crop Insurance has been launched which will cover the risk factor involved in production of seeds.

ix) Seed Bank Scheme: About 7-8 percent of certified seeds produced in the country will be kept in buffer stock to meet any eventualities arising out of drought, floods or any other form of natural calamities.

x) Cooperative Sector Reforms: Amendment to the National Cooperative Development Corporation (NCDC) Act, 1952, and Replacement of the Multi-State Cooperative Societies (MSCS) Act, 1984.

All these measures will lead to crop diversification and increase the production and productivity of crops.

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EATING DISORDERS: IT'S NEVER TOO LATE TO STOP

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Introduction

In the vast and often tumultuous spectrum of mental health, eating disorders stand as a formidable challenge. These disorders, characterized by abnormal eating habits negatively impact individual's physical and mental well-being. They are complex and multifaceted that can affect anyone, regardless of age, gender, or background. Nevertheless, the perception is that they primarily afflict adolescents and young adults, however, the reality is that they can persist well into adulthood, presenting several challenges to recovery. They encompass a range of disarrays like anorexia nervosa, bulimia nervosa, binge eating disorders, and others. Despite the daunting nature of these disorders, one resounding message remains: it's never too late to stop.

Understanding Eating Disorders

To comprehend the complexities of eating disorders, one must delve into their underlying causes and manifestations. The exact cause of eating disorders is not fully understood, researchers believe that a combination of genetic predisposition, societal pressures, and individual temperament play significant roles in their development. While societal pressures, unrealistic body standards, and cultural influences undoubtedly play a role, eating disorders are often rooted in deeper psychological and emotional issues. Individuals may turn to disordered eating patterns as a means of coping with stress, trauma, low self-esteem, or a desire for control in their lives. The biological factors, including abnormalities in brain chemistry and neurotransmitter function, may also play a role in the development of eating disorders. Certain neurotransmitters, such as serotonin and dopamine, are involved in regulating mood, appetite, and impulse control, and abnormalities in these systems may contribute to the development of disordered eating behaviours. Nevertheless, environmental factors, such as a history of childhood trauma, family dynamics, and peer influences, can also contribute to the development of eating disorders.

Types

Eating disorders encompass a range of conditions, each characterized by distinct patterns of disordered eating behaviour and associated symptoms. Some of the most common types of eating disorders include:

Anorexia Nervosa:

It is characterized by extreme calorie restriction, fear of weight gain, and a distorted body image. Individuals may severely restrict their food intake, leading to significant weight loss and malnutrition. They may also engage in excessive exercise to control their weight. Anorexia nervosa can have serious physical and psychological consequences, including organ damage, infertility, and even death if left untreated.

Bulimia Nervosa:

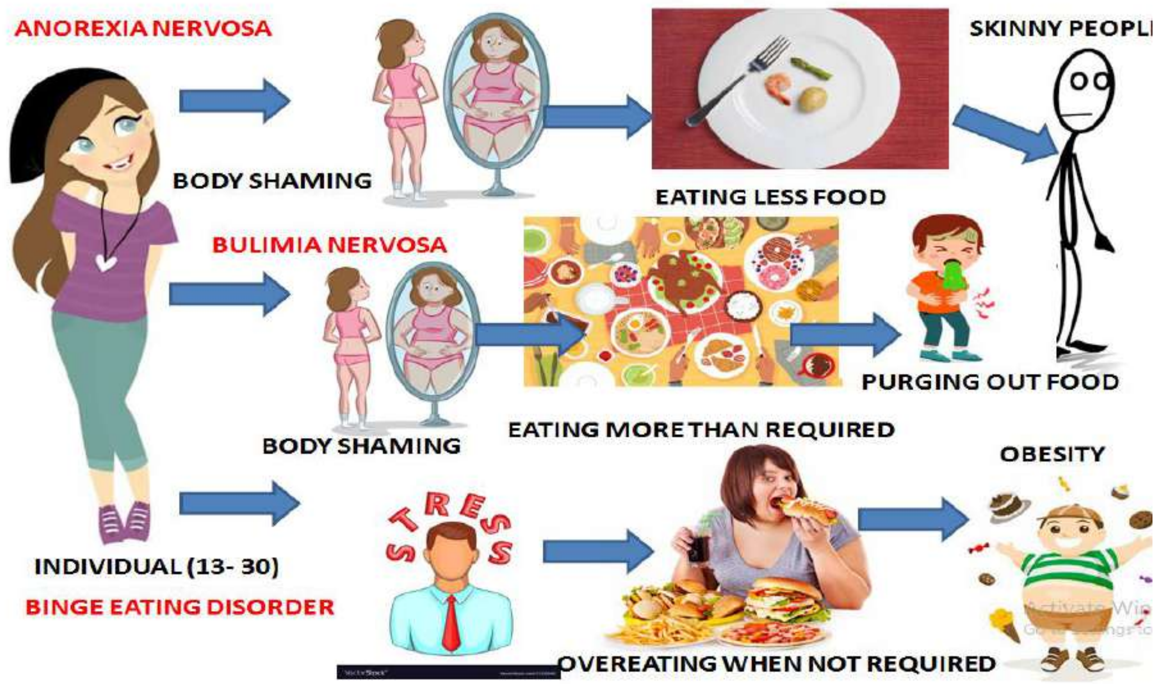
It involves cycles of binge eating followed by purging behaviours, such as self-induced vomiting, laxative abuse, or excessive exercise. Individuals may consume large quantities of food in a short period, often feeling a loss of control during binge eating episodes. They may then attempt to compensate for the calories consumed by engaging in purging behaviours. It can have serious physical consequences, including electrolyte imbalances gastrointestinal problems, and dental issues.

Binge Eating Disorder:

It is characterized by recurrent episodes of binge eating, during which individuals consume large quantities of food in a short period and experience a loss of control over their eating behaviour. Unlike bulimia nervosa, individuals with binge eating disorder do not engage in purging behaviour afterwards. The episodes may be triggered by emotional distress or other psychological factors, and individuals may experience feelings of guilt, shame, or embarrassment following episodes of overeating. It is associated with an increased risk of obesity and related health complications, including diabetes, heart disease, and hypertension.

Other Specified Feeding Eating Disorders (OSFED):

OSFED, formerly known as Eating Disorder Not Otherwise Specified (EDNOS), is a category that includes eating disorders that do not meet the criteria for anorexia nervosa, bulimia nervosa, or binge eating disorder. This may include a typical presentation of these disorders, as well as other forms of disordered eating behaviour that cause significant distress or impairment but do not fit neatly into existing diagnostic categories.



Symptoms and treatment of eating disorders

Eating disorders	Symptoms	Treatment
Anorexia nervosa	Extreme weight loss, skinny, fatigue, insomnia, dizziness, dehydration, low blood pressure.	Psychological monitoring, cognitive behavior therapy, personal psychiatrists, take help of dietician.
Bulimia nervosa	Abnormal eating, using laxatives, burden of body shape, fasting, use of diuretics, sleepiness, weakness.	Psychological monitoring, cognitive behavior therapy, family, socialize.
Binge eating	Anxiety, tension, depression, overeating, eating at night time, eating in bulk without being hungry.	Antidepressants, cognitive behavior therapy, personal psychiatrists, take help of dietician.

Examples of OSFED include typical anorexia nervosa (where individuals may exhibit all of the symptoms of anorexia nervosa but are not underweight), purging disorder (where individuals engage in purging behaviours without binge eating), and night eating syndrome (where individuals consume a large portion of their daily caloric intake during nighttime waking hours).

Breaking the Stigma

Despite the prevalence and severity of eating disorders, there remains a significant stigma surrounding these conditions, particularly among older adults. The misconception that eating disorders only affect the young can prevent older individuals from seeking help and receiving the support they desperately need. Moreover, societal attitudes that equate thinness with beauty and self-control can exacerbate feelings of shame and guilt in those struggling with disordered eating. It's essential to challenge these harmful stereotypes and foster a more compassionate and understanding approach to eating disorders at any age. By destigmatizing these conditions and promoting open dialogue, we can encourage individuals of all ages to seek help without fear of judgment or discrimination.

The Road to Recovery

Recovery from an eating disorder is a journey accompanied with challenges, setbacks, and triumphs. For older adults, the path to healing may be further complicated by factors such as co-occurring medical conditions, life transitions, and ingrained patterns of behaviour that have persisted for decades. However, with the right support system and treatment approach, recovery is entirely possible. Therapy, at both individual and group level, plays a central role in the treatment of eating disorders. Cognitive-behavioural therapy (CBT), dialectical behaviour therapy (DBT), and interpersonal therapy (IPT) are among the evidence-based approaches that can help individuals address underlying issues, challenge distorted thoughts and beliefs, and develop healthier coping mechanisms. Additionally nutritional counselling plays an important role in restoring a healthy relationship with food and promoting balanced eating habits. Registered dietitians can work with individuals to create personalized meal plans, address nutritional deficiencies, and steer challenges such as food avoidance or fear foods. In some cases, medication may be prescribed to manage co-occurring conditions such as depression, anxiety, or obsessive-compulsive disorder (OCD), which frequently accompany eating disorders. However, medication alone is rarely sufficient and is typically used in conjunction with therapy and other forms of treatment.

Embracing Self-Compassion

The cultivation of self-compassion and acceptance is central to the recovery process. Many individuals with eating disorders harbour deep-seated feelings of shame, self-loathing, and inadequacy, which can perpetuate the cycle of disordered eating resulting into its manifestation. Learning to treat oneself with kindness and understanding, rather than harsh criticism, is a fundamental aspect of healing. Mindfulness practices, such as meditation and yoga, can be powerful tools for cultivating self-awareness and compassion. By tuning into the present moment without judgment, individuals can begin to observe their thoughts and emotions with greater clarity, fostering a sense of inner peace and acceptance. Building a strong support network is also crucial on the journey to recovery. Friends, family members, therapists, and support groups can provide invaluable encouragement, validation, and practical assistance during challenging times. Connecting with others who have walked a similar path can offer reassurance and solidarity, reminding individuals that they are not alone in their struggles.

Conclusion: A Message of Hope

The intricacies of eating disorders, coupled with the challenges of confronting them, can overwhelm individuals and leave them disheartened and defeated. The road to recovery may stretch long and arduous, peppered with obstacles and setbacks. Nonetheless, it's essential to recognize that healing is achievable, regardless of the duration of the struggle. It's never too late to intervene and seek support, to embark on a journey of self-discovery and transformation, and to reclaim a life free from the shackles of disordered eating. If you or someone you know is grappling with an eating disorder, remember that assistance is within reach or at your doorstep. Reach out to a trusted healthcare professional, therapist, or support group to begin the journey on the path towards recovery.

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PHYTOREMEDIATION OF SALT AFFECTED SOILS

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Abstract

Salt-affected soils are widely spread on many continents of the world, constituting about 831 M ha. Salt-prone soil degradation has triggered imbalances between the functions supplied by natural resources and the demands of societies that exploit these functions. Since such degradation occurs both ‘‘on-site’’ and ‘‘off-site,’’ it affects the livelihoods within and outside the farming communities. Phytoremediation is a technique that uses plants to mitigate salt contaminants in soils. Phytoremediation of sodic and saline-sodic soils is contingent on increasing the dissolution rate of calcite through processes at the soil-root interface, resulting in enhanced levels of Ca^{2+}in the soil solution. The use of plant and tree species is a valuable method to control soil salinity through a low-cost, effective method while at the same time improving the soil properties.

Key words: Phytoremediation, Salt affected soils, degradation and soil-root interface.

Introduction

Soil salinity severely diminishes available vegetative lands; as a result, much effort has been put into research on economical and effective methods to restore vegetation on these salt-impacted soils. Conventional methods for removal of salt from soil include disposal of surface layers and soil washing. However, these methods are impractical, labour intensive, expensive, and destructive to soil structure. For the aforementioned reasons, phytoremediation has been studied extensively for the past 30 years as a potential solution to restoring salt-impacted lands (USEPA 2000). Phytoremediation is a technique that uses plants to mitigate organic or inorganic contaminants in soils. This technique has been widely studied to remediate metals, petroleum waste, pesticides, and salt-impacted soils (Bose *et al.*, 2008)

Salt Affected Soils

Salt affected soils are wide spread on many continents of the world, constituting about 831 Mha (Martinez and Manzur, 2005) Table1. There are two major types of salt affected soils, namely saline and alkali soils. Salt-affected soils are an important category of degraded soils and the severe effects that soil salinity and sodicity have on agricultural productivity. Worldwide, approximately one billion hectares of land are salt affected (Wicke *et al.,* 2011). Salt-prone soil degradation has triggered imbalances between the functions (goods and services) supplied by the natural resources (land and water) and the demands of societies that exploit these functions. Since such degradation occurs both ‘‘on-site’’ and ‘‘off-site,’’ it affects the livelihoods within and outside the farming communities. In comparison with the biophysical aspects, the social and economic dimensions of salt induced soil degradation have received little attention. It is generally recognized that a large proportion of these soils occur on land inhabited by smallholder farmers, who rely on this resource to satisfy their food and feed needs (Qadir *et al.*, 2006).

Table1. Salt Affected Soils

	Salt affected soils	Sodic soils	Saline soils
World (million ha)	831.4	434.3	380
India (million ha)	6.74	2.96	3.77
Tamil Nadu (ha)	3,68,015	13,231	3,54,784

Global/Regional Distribution (M.ha) of salt affected soils

Salt-affected soils occur within the boundaries of at least 75 countries. These soils also occupy more than 20% of the global irrigated area, in some countries, they occur on more than half of the irrigated land. Over the last few decades, salt-prone soil degradation has increased steadily in several major irrigation schemes throughout the world. Examples include Indo-Gangetic Basin in India), Indus Basin in Pakistan, Yellow River Basin in China, Euphrates Basin in Syria and Iraq, Murray-Darling Basin in Australia, and San Joaquin Valley in the United

States. Salt- and irrigation induced soil degradation is prevalent in the Aral Sea Basin of Central Asia with the consequent environmental changes in that region being considered as the largest ones caused by humanity.

Most of the developing countries in Asia are facing the daunting challenge of managing their ever increasing human and cattle population, to meet the requirement of food, fuel wood and fodder *etc.*, Table. 2. There is fragmentary information available regarding the restoration of productivity and fertility of degraded sodic soils through tree plantation (Bhojvaid *et al.*, 1996). However, the development of mixed forest tree species on sodic wastelands, apart from providing diverse needs and services to the society, ameliorates the soil to various degrees. This appears as a function of species diversity, productivity and decomposition process.

Table. 2 Global/Regional Distribution (m.ha) of salt affected soils

Region	Total area	Saline soil	Sodic soil	Total
Africa	1899	38.7	33.5	72.2
*Asia & Aus	3107	195.1	278.6	443.7
Europe	2011	6.7	72.7	79.4
Latin America	2039	60.5	50.9	111.4
Near East	1802	91.5	14.5	105.6
North America	1924	4.6	14.5	19.1
Total	12782	397.1	434.3	831.4

* Asia pacific & Australia.

Source: International Journal of Ecology and Environmental Sciences 31 (1) : 53-66,2009. National Institute of Ecology, New Delhi.

Salt affected soils are characterized by the occurrence of sodium (Na^+). These soils can be brought back to a highly productive state by providing a soluble source of calcium (Ca^{2+}) to replace excess Na^+ on the cation exchange complex. Many Salt affected soils contain inherent or precipitated sources of Ca^{2+}, typically calcite ($CaCO_3$), at varying depths within the profile. The ability of the soil solution to carry an electrical current. Measured by passing an electrical current through a soil solution extracted from a saturated soil sample

Table 3. Classification of salt affected soils (NRCS)

Salt-affected Soil	**EC (dS m^{-1})**	**Soil pH**	**Sodium Adsorption Ratio**
Saline	> 4.0	< 8.5	< 13
Saline-sodic	> 4.0	< 8.5	> 13
Sodic	< 4.0	> 8.5	> 13

Problems due to salinity

- Soil particle flocculated and aggregate
- Poor soil physical properties
    - Very poor water and air movement
    - Lesser Root penetration
    - O_2 deficiency due to poor soil structure
- Osmotic potential
- Collapsing cells
- Toxicity of bicarbonate
- Low micronutrient availability
- poor and spotty stands of crops,
- Uneven and stunted growth and poor yields

Phytoremediation

Phytoremediation is the use of plants to treat/clean contaminated sites (Malcolm et al, 2010) Phytoremediation, the use of plants to extract, sequester, and/or detoxify pollutants, has been reported to be an effective, non-intrusive, inexpensive, aesthetically pleasing, socially accepted technology to remediate polluted soils (Garbisu et al. 2002). Phytoremediation is widely viewed as the ecologically responsible alternative to the environmentally destructive physical remediation methods currently practiced. Phytoremediation is particularly effective when used on moderately salinesodic and sodic soils. It is a viable solution for resource-poor farmers through community-based management, which would help in strengthening the linkages among researchers, farm advisors, and farmers. These linkages will continue to be fostered as the use of sodic soils becomes more prevalent.

The success of phytoremediation of sodic soils requires a greater understanding of the processes fostering phytoremediation, the potential of plant species to withstand ambient salinity and sodicity levels in soil and water, and also of the uses and markets for the agricultural products produced. Strategic research on such aspects would further elucidate the role of phytoremediation in the restoration of sodic soils for sustainable agriculture and conservation of environmental quality.

Phytoremediation - salt affected soils

Sodic and saline-sodic soils are ameliorated by the provision of a readily available source of Ca^{2+} to replace excess Na^+ on the cation exchange complex. The displaced Na^+ is leached from the root zone through the application of excess irrigation water. This requires adequate amounts of water and unimpeded flow through the soil profile as well as the provision of natural or artificial drainage systems (Garg 1999), which plays an important role in the management of drainage water in a sustainable manner. Considering the fact that sodic soil amelioration is accomplished by providing a source of Ca^{2+}, most sodic and saline-sodic soils do contain a source of Ca^{2+} that is calcite ($CaCO_3$), at varying depths within the soil profile.

Calcite may be a constituent of the parent material or formed in situ through precipitation as coatings on soil particles and in pores that may result in cementation of particles. However, due to its negligible solubility (0.14 mmol liter^{-1}), natural dissolution of calcite does not provide sufficient quantities of Ca^{2+} to affect soil amelioration at partial pressures of carbon dioxide (PCO_2) that are typically present in the atmosphere. A further common Ca^{2+} -containing mineral in sodic and saline-sodic soils is dolomite. The solubility of dolomite is several-fold less than calcite. The more soluble $CaCO_3$ minerals such as vaterite, aragonite, or $CaCO_3$ hydrates are not commonly found in soils or observed to form pedogenically. Consequently, amelioration of these soils has been predominantly achieved through the application of chemical amendments In this respect, amendments such as gypsum ($CaSO_4 .2H_2O$) supply soluble sources of Ca^{2+} to the soil solution, which then replace excess Na^+ on the exchange complex. Other amendments such as sulfuric acid (H_2SO_4) assist in increasing the dissolution rate of calcite to release adequate amounts of Ca^{2+} in soil solution

Mechanisms involved in the Phytoremediation of Salt affected soils

Phytoremediation of calcareous sodic and saline-sodic soils (PhytoSodic) assists in enhancing the dissolution rate of calcite through processes at the soil–root interface resulting in increased levels of Ca^{2+} in soil solution.

- $Phyto_{Sodic} = R_{PCO_2} + R_{H+} + R_{Phy} + S_{Na+}$

Where,

R_{PCO_2} - Dissolution of soil Ca^{2+} by increased partial pressure of CO_2

R_{H+} - Proton release by plant roots

R_{Phy} - Physical effect of roots

S_{Na+} - Salt and Na^+ uptake by shoots, Which is removed through harvest of the aerial plant portion. The collective effects of these factors ultimately lead to soil amelioration, provided drainage is present and adequate leaching occurs.

Partial pressure of CO_2 in the root zone

Dissolution and precipitation kinetics of calcite are determined by the chemistry of the system. Fig1. A typical reaction for the dissolution of calcite may be expressed as a function of CO_2 in the root zone. A typical reaction for the dissolution of calcite may be expressed as a function of CO_2 in the root zone, summarizes three processes (Basavaraja et al, 2007), which occur concurrently: (1) conversion of CO_2 in an aqueous matrix, such as soil solution, into H_2CO_3 and its reaction with $CaCO_3$); (2) dissociation of H_2CO_3 into $H^+$and HCO_3^- and the reaction of H^+ with $CaCO_3$ as presented and (3) dissolution of $CaCO_3$ resulting in Ca^{2+} and CO_3^{2-}

Root respiration is not the only mechanism influencing PCO_2 in the root zone. It is also affected by the following mechanisms that can act individually or collectively: (1) production of CO_2 from oxidation of plant root exudates as soil organisms assist in producing CO_2 when they oxidize polysaccharides, proteins, and peptides; and (2) production of organic acids by soil organisms, which help in dissolving calcite. Regardless of the source of CO_2 production in soils, whether it be from respiring roots, decomposing organic matter and root exudates, or organic acid dissolution of calcite, the end result is the same: Ca^{2+} becomes available to replace exchangeable Na+ at a much higher rate than can be achieved by dissolution of calcite at thelevel of PCO_2 in the atmosphere.

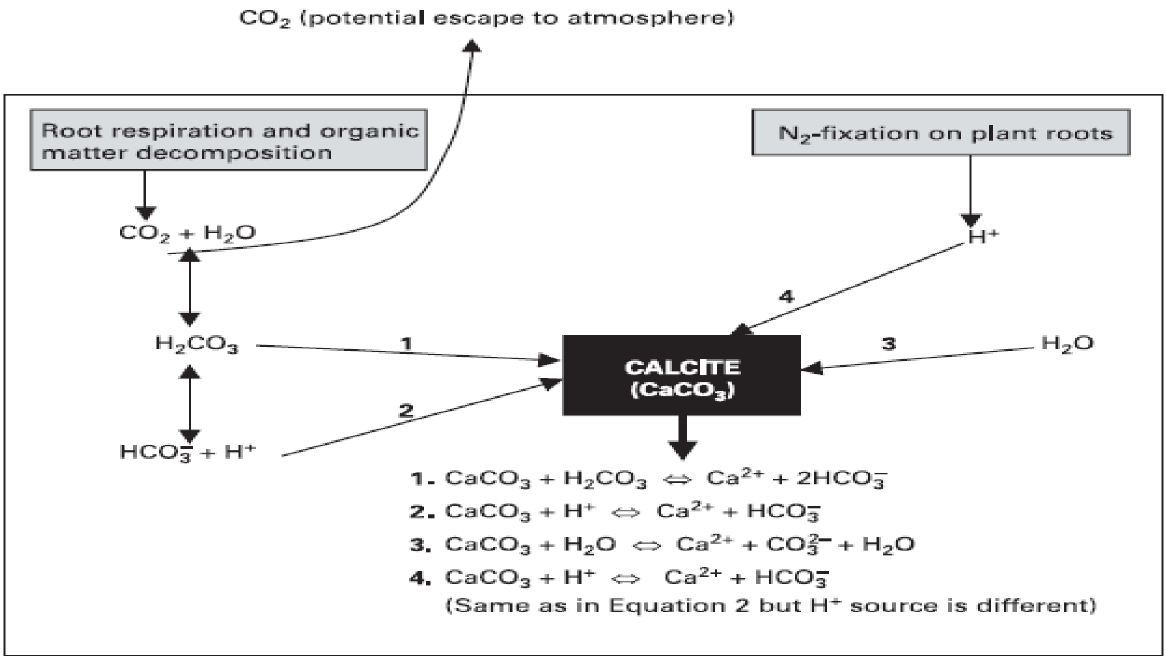

Fig1. A model of the chemical reactions involved in the dissolution of calcite (CaCO3) during phytoremediation of calcareous sodic and saline-sodic soils.

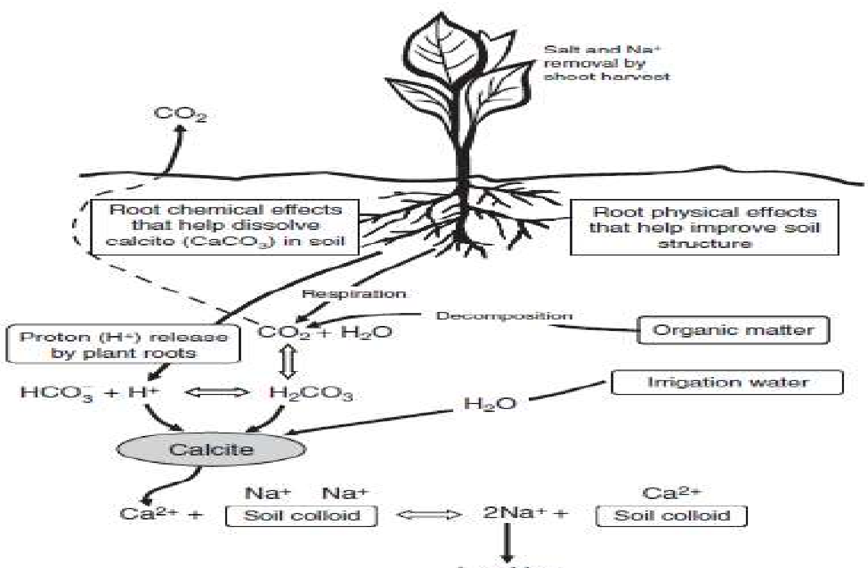

Fig 2. Schematic illustration of driving forces for phytoremediation of calcareous sodic and saline-sodic soils: increased partial pressure of CO_2 within the root zone; enhanced proton (H^+) release in the root zone in case of certain crops; physical effects of roots in improving soil aggregation and hydraulic properties of the root zone; and salt and sodium (Na^+) content of shoot, which is removed through harvest of aerial plant portion.

Proton release by plant roots

The Release of H^+ from plant roots is considered as a process contributing to a decrease in pH of the rhizosphere. Legumes relying on symbiotic N_2 fixation have been shown to acidify their rhizosphere (Schubert and yan 1997). In addition, legumes relying on symbiotic N2 fixation have been shown to acidify their rhizosphere (Schubert & Yan 1997). Although considerable H^+ extrusion has been recorded in the rhizosphere of various N2-fixing plant species, this biological acidification mechanism has been studied mainly in acidic soils rather than with regard to its possible role in remediation of sodic and saline–sodic soils. Proton release by plants at the soil–root interface results in an electrochemical gradient. Cation uptake increases net H+ release through partial depolarization of the membrane potential, which facilitates active H+ pumping. Proton release is chemically balanced in the external medium by the release of organic anions. Hence, the organic anion complement of a crop or the litter component of trees is a measure of the net H+ release at the root–soil interface, which has been named the ash alkalinity (Akhter et al., 2004).

Considerable H^+ extrusion has been recorded in the rhizosphere of various N_2-fixing plant species this biological acidification mechanism has been studied mainly in acidic soils rather than its possible role in the remediation of sodic and saline-sodic soils (Schubert *et al.,* 1990).

Protons released by N_2-fixing plant species in the root zone of sodic soils assist in calcite dissolution resulting in Ca^{2+} and HCO_3^-.

$$\mathbf{CaCO_3 + H^+ \rightarrow Ca^{2+} + HCO_3}$$

Physical effects of roots

Plant roots are essential for maintaining soil structure, and the presence of roots at the lower depths of the soil profile drives the processes of macropore formation. Plant roots improve soil porosity by creating either biopores or structural cracks (Yunusa and Newton, 2003). Plant roots play an important role in facilitating the process of leaching Na+, replaced from the cation exchange complex, to the deeper soil layers. Process can be triggered by deep-rooted vegetation that can withstand ambient levels of salinity and sodicity during phytoremediation (Akhter *et al.,* 2004).

Salt and Na^+ uptake by shoots

Removal of aboveground biomass of plant species, used for phytoremediation of sodic and saline-sodic soils, removes salts and Na^+ taken up by the plants and accumulated in their shoots. Highly salt-resistant species such as halophytes may accumulate quite high levels of salts and Na^+ in their shoots. For example, Atriplex species grown under rangeland conditions have leaf ash concentrations 130–270 g salts kg^{-1} (Hyder, 1981) and if grown in salt affected soils, the species can have leaf ash concentrations as high as 390 g salt kg^{-1} (Malcolm *et al.*, 1988). Despite these high levels of salt removal via shoot harvest of the plant species, such salt removal alone does not play a significant role in the amelioration process of salt-affected soils, which contain huge amounts of salts.

Perennial grasses and pastures

Deep-rooted grasses also enhance the SOC pool and reclaim salt-affected soils. Several studies have shown that growing Karnal/Kallar grass has strong ameliorative effects.

Impact of *Acacia nilotica* plantation on saline sodic soil

Acacia nilotica is a leguminous tree species commonly found in interior Karnataka on sodic soils was evaluated for its potentiality to reclaim the sodic soil in Hosadurga taluk of Chitradurga district, Central dry zone of Karnataka (Barrett-Lennard, 2002), This can be concluded that *Acacia nilotica* tree species is able to rehabilitate the sodic soil and this trees species not only grows well in harsh sodic conditions but also can ameliorate the saturation extract properties. The pHs, ECe, ESP and SAR decreased whereas, the concentration of Ca^{2+} and $Mg^{2+,}$ organic carbon content, CEC and available major nutrients status of soil increased in the soil profile, which clearly indicated its effectiveness in reclamation of sodic soils.

Table 4. Tolerant grass species for alkali soils

Grass species	**Local name**
Diplachne fusca (more tolerant species at ESP of 60)	Karnal grass
Chloris gayana (more tolerant species at ESP of 60)	Rhodes grass
Cynodon dactylon	Bermuda grass
Brachiaria mutica	Para grass
Panicum species	Blue panic

Table 5. Tolerant species for saline soils tried in India

Very high salt-tolerant ECe > 35 dS/m	
Trees/ shrubs	*Prosopis juliflora, Salvadora persica, S. oleoides, Tamarix ericoides, T. troupii, Salsola baryosma etc.*
High salt-tolerant (ECe > 25-35 dS/m)	
Trees/ shrubs	*Tamarix articulata, Acacia farnesiana, Parkinsonia aculeata*
Tolerant (ECe 15-25 dS/m)	
Trees/ shrubs	*Casuarina (glauca, obesa, equiselifolia), Acacia tortilis, A. nilotica, Callistemon lanceolata, Pongamia pinnata, Eucalyptus camaldulensis, Crescentia alata, Albizia lebbeck.*
Grasses/forbs	*Ziziphus nummularia, species of Chenopodium, Dichanthium, Eragrostis, Panicum, Spartina, Paspalum, Sporobolus, Brachiaria, Chloris.*
Moderately tolerant (ECe 10-15 dS/m)	
Trees/ shrubs	*Casuarina cunninghamiana, Eucalyptus tereticornis, Acacia catcechu, A. ampliceps, A. eburnea, A. leucocephala, Terminalia arjuna, Samanea saman, Albizia procera, Borassus flabellifer, Prosopis cineraria, Azadirachta indica, Dendrocalamus strictus, Butea monosperma, Cassia siamea, Feronia limonia, Leucaena leucocephala, Tamarindus indica, Guazuma ulmifolia, Ailanthus excelsa, Dichrostachys cinerea, Balanites roxburghii, Maytenus emarginatus, Dalbergia sissoo, Salix babylonica*
Grasses/forbs	*Andropogon annulatus, Anthistria prostrata, Paspalum notatum, Urochloa mossiambicensis, Glycine javanica, Phaseolus lunata, Cenchrus pennisetiformis, Lasiurus sindicus, Echinochloa colonum, etc.*

Merits

- No financial outlay to purchase chemical amendments
- Promotion of soil-aggregate stability and formation of macropores
- Greater plant nutrient availability
- Environmental consideration in terms of Carbon sequestration
- It is potentially the least harmful method

Demerits

- More slow than chemical approaches
- Feasibility of phytoremediation is limited when soil is highly sodic, as this is likely to result in poor growth of the phytoremediation crop's
- It is limited to the surface area and depth occupied by the roots.
- Slow growth and low biomass require a long-term commitment.

Conclusions

In recent decades, phytoremediation has proved to be an efficient, inexpensive and environmentally acceptable strategy to ameliorate calcareous sodic and saline-sodic soils. (Qadir and Oster, 2006). Phytoremediation of sodic and saline-sodic soils is contingent on increasing the dissolution rate of calcite through processes at the soil-root interface, resulting in enhanced levels of Ca^{2+}in the soil solution. This is an effective low-cost intervention in their amelioration, environmentally sound technology for remediation of salt-impacted sites if it can be properly developed and is a viable solution for farmers.

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NUTRIENT MANAGEMENT IN ORGANIC FARMING

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Organic farming

The organic farming is the production of crops, animals and others without using the chemical fertilizers, genetically modified plants and chemical pesticides. The USDA defines organic agriculture as "a production system that is managed to respond to site-specific conditions by integrating cultural, biological and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity." According to the survey of Research Institute of Organic Agriculture (2017), there are 181 countries with 69.8 mha of organic farming lands which is 1.4% of the total agricultural land. Oceania occupies the largest world organic production. The total organic farming land in Asia is 6.1mha from which 1.1 million producers are from India. The green revolution results in use of chemical fertilizers extensively. This leads to pollution which has the adverse effect on climate. Organic farming helps to overcome these hazardous consequences.

Nutrient Management in Organic Farming

Because chemical fertilizers and micronutrients are not utilized in organic farming, managing nutrients can be difficult. Management of the soil's biological health, physical state, and nutritional status are all included in nutrient management.In organic farming, there are many different ways to supply nutrients. They are,

i. Crop rotation
ii. Cover cropping

iii. Addition of compost
iv. Green manures/Green leaf manures
v. Addition of manures
vi. Application of crop residues
vii. Use of biofertilizers

i. Crop rotation

The crop rotation improves soil physical properties (pH, CEC, bulk density), nutrient availability (total nitrogen, available phosphorus, exchangeable potassium) , pest management, nutrient use efficiency and crop yield. Monoculture leads to decrease in the soil nutrients. A legume in the crop rotation helps to replenish the nitrogen in the soil. Growing of legume will make the nitrogen available for succeeding crop. Crop rotation with non host crops helps to break the life cycle of pests or it helps to decrease the rate of population of the pests. Crop rotation with crops having different root architecture helps in use of nutrients in different soil layers.

ii. Cover cropping

The cover crops are grown in between the main crop or grown during the season where the main crops are not grown. They are generally fast growing crops which are not competitive for the main crop. Cover cropping has a role in preventing soil erosion, increase nutrient availability and promote the organic matter of the soil. The cover crops are mostly leguminous plants. These plants act as green manure. They provide additional nitrogen through symbiotic relationship with rhizobial bacteria. The cover crop biomass increases the soil organic matter. So the water holding capacity and soil structure is improved.

iii. Addition of compost

Composting is the process of decomposition of organic matter by microorganisms under controlled conditions. The product of composting is called compost. The organic materials such as crop wastes, food wastes, animal wastes, municipal wastes, industrial wastes are suitable for composting. It increases the soil physical, chemical and biological properties. Compost provides nutrients in a stable organic form and increases plant rooting depth, plant growth and health. It also improves soil microbial activity and water holding capacity of soil.

iv. Green manures/Green leaf manures

Green Manure

Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest. Green manuring is growing in the field plants usually belonging to leguminous family and incorporating into the soil after sufficient growth. The plants that are grown for green manure known as green manure crops. The most important green manure crops are sunnhemp, dhaincha, pillipesara,clusterbeans and Sesbania rostrata.

Advantages

i. Improves soil structure
ii. Increases water holding capacity and
iii. Decreases soil loss by erosion

Green Leaf Manure

Application of green leaves and twigs of trees, shrubs and herbs collected from elsewhere is known as green leaf manuring. Forest tree leaves are the main sources for green leaf manure. Plants growing in wastelands, field bunds etc., are another source of green leaf manure. The important plant species useful for green leaf manure are neem, mahua, wild indigo, Glyricidia, Karanji *(Pongamia glabra)* calotropis, avise*(Sesbania grandiflora)*, subabul and other shrubs.

Advantages

i. Green manuring improves soil structure, increases water holding capacity and decreases soil loss by erosion.
ii. Growing of green manure crops in the off season reduces weed proliferation and weed growth.
iii. Green manuring helps in reclamation of alkaline soils. Root knot nematodes can be controlled by green manuring.

v. Manuring:

Manures are the animal or plant wastes which release nutrients slowly by biological decomposition. Manures are grouped into bulky and concentrate organic manure. Bulky organic manures contain small amount of nutrients and should be applied in large quantities which constitute farm yard manure, poultry manure. Concentrate organic manures have large amount of nutrients so it should by applied in small quantities. It includes edible and non edible oil cakes, blood meal, horn meal, hoof meal, bone meal and fish meal.

Bulky organic manure

Organic manure	N(%)	P(%)	K(%)
Cow Manure	0.6	0.4	0.5
Pig Manure	0.8	0.7	0.5
Poultry Manure	1.1	0.8	0.5
Sheep Manure	0.7	0.3	0.9

Average nutrient content of oil cakes

Oil-cakes	**Nutrient content (%)**		
	N	**P2O5**	**K2O**
Non edible oil-cakes			
Castor cake	4.3	1.8	1.3
Cotton seed cake (undecorticated)	3.9	1.8	1.6
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.2
Safflower cake (undecorticated)	4.9	1.4	1.2
Edible oil-cakes			
Coconut cake	3.0	1.9	1.8
Cotton seed cake (decorticated)	6.4	2.9	2.2
Groundnut cake	7.3	1.5	1.3
Linseed cake	4.9	1.4	1.3
Niger cake	4.7	1.8	1.3
Rape seed cake	5.2	1.8	1.2
Safflower cake (decorticated)	7.9	2.2	1.9
Sesamum cake	6.2	2.0	1.2

Other Concentrated Organic Manures

Blood meal when dried and powdered can be used as manure. The meat of dead animals is dried and converted into meat meal which is a good source of nitrogen. Average nutrient content of animal based concentrated organic manures is given as follows.

Average nutrient content of animal based concentrated organic manures

Organic manures	Nutrient content (%)		
	N	**P2O5**	**K2O**
Blood meal	10 - 12	1 - 2	1.0
Meat meal	10.5	2.5	0.5
Fish meal	4 - 10	3 - 9	0.3 - 1.5
Horn and Hoof meal	13	-	-
Raw bone meal	3 - 4	20 - 25	-
Steamed bone meal	1 - 2	25 - 30	-

Crop residues

In India about 141 million tons of crop residues are produced per year, out of which 92 mt is burned each year. The two crops such as rice and wheat are produced large amount of residues in India. These crop residues can be incorporated directly into the field or can be used for composting processes. It plays important role in maintaining the soil carbon content and phosphorus availability .It provides soil organic matter, which improves the quality of the seedbed and increases the water infiltration and water holding capacity of the soil, balances the pH . It also sequester Carbon in the soil.

Use of biofertilizer

A biofertilizer is a substance which contains living micro-organisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Biofertilizers make the nutrients available to the plants. There are various types of bioferilizers.

i. Nitrogen fixing bioferilizers
ii. Phosphorus solubilizing bioferilizers
iii. Phosphorus mobilizing bioferilizers
iv. Zinc solubilizing bioferilizers
v. Sulphur solubilizing biofertilizers
vi. Plant growth promoting rhizobactria

Liquid Biofertilizers

Biofertilizers are such as *Rhizobium*, *Azospirillum* and Phosphobacteria provide nitrogen and phosphorous nutrients to crop plants through nitrogen fixation and phosphorous solubilization processes. These Biofertilizers could be effectively utilized for rice, pulses, millets, cotton, sugarcane, vegetable and other horticulture crops. Biofertilizers is one of the prime input in organic farming not only enhances the crop growth and yield but also improves the soil health and sustain soil fertility. At present, Biofertilizers are supplied to the farmers as carrier based inoculants. As an alternative, liquid formulation technology has been developed in the Department of Agricultural Microbiology, TNAU, Coimbatore which has more advantages than the carrier inoculants.

Benefits

The advantages of Liquid Bio-fertilizer over conventional carrier based Bio-fertilizers are listed below:

- Longer shelf life -12-24 months.
- No contamination.
- No loss of properties due to storage upto 45º c.
- Greater potentials to fight with native population.
- High populations can be maintained more than 109 cells/ml upto 12 months to 24 months.
- Easy identification by typical fermented smell.
- Cost saving on carrier material, pulverization, neutralization, sterilization, packing and transport.
- Quality control protocols are easy and quick.
- Better survival on seeds and soil.
- No need of running Bio-fertilizer production units through out the year.
- Very much easy to use by the farmer.
- Dosages is 10 time less than carrier based powder Bio-fertilizers.
- High commercial revenues.
- High export potential.
- Very high enzymatic activity since contamination is nil.

Dosage of liquid Bio-fertilizers in different crops

Recommended Liquid Bio-fertilizers and its application method, quantity to be used for different crops are as follows:

Crop	Recommended Bio-fertilizer	Application method	Quantity to be used
Field crops Pulses Chickpea, pea, Groundnut, soybean, beans, Lentil, lucern, Berseem, Green gram, Black gram, Cowpea and pigeon pea	*Rhizobium*	Seed treatment	200ml/acre
Cereals Wheat, oat, barley	*Azotobacter/Azospirillum*	Seed treatment	200ml/acre
Rice	*Azospirillum*	Seed treatment	200ml/acre
Oil seeds Mustard, seasum, Linseeds, Sunflower, castor	*Azotobacter*	Seed treatment	200ml/acre
Millets Pearl millets, Finger millets, kodo millet	*Azotobacter*	Seed treatment	200ml/acre
Maize and Sorghum	*Azospirillum*	Seed treatment	200ml/acre
Forage crops and Grasses Bermuda grass, Sudan grass, Napier Grass , ParaGrass, StarGrass etc.	*Azotobacter*	Seed treatment	200ml/acre
Other Misc. Plantation Crops Tobacco	*Azotobacter*	Seedling treatment	500ml/acre
Tea, Coffee	*Azotobacter*	Soil treatment	400ml/acre
Rubber, Coconuts	*Azotobacter*	Soil treatment	2-3 ml/plant
Agro-ForestRY/Fruit Plants All fruit/agro-forestry (herb,shrubs, annuals and perennial) plants for fuel wood fodder, fruits,gum,spice,leaves,flowers,nuts and seeds puppose	*Azotobacter*	Soil treatment	2-3 ml/plant at nursery
Leguminous plants/ trees	*Rhizobium*	Soil treatment	1-2 ml/plant

Beneficial effects of Panchagavya on commercial crops

Mango

- Induces dense flowering with more female flowers
- Irregular or alternate bearing habit is not experienced and continues to fruit regularly
- Enhances keeping quality by 12 days in room temperature
- Flavour and aroma are extraordinary

Guava

- Higher TSS
- Shelf life is extended by 5 days

urmeric

- Enhances the yield by 22%
- Extra long fingers
- Ensure low drainage loss
- Narrows the ratio of mother and finger rhizomes
- Helps survival of dragon fly, spider etc which in turn reduce pest and disease load
- Sold for premium price as mother/seed rhizome
- Enriches the curcumin content

Vegetables

- Yield enhancement by 18% and in few cases like Cucumber, the yield is doubled
- Wholesome vegetables with shiny and appealing skin
- Extended shelf life
- Very tasty with strong flavour

Acid lime

- Continuous flowering is ensured round the year
- Fruits are plumpy with strong aroma
- Shelf life is extended by 10 days

Banana

- In addition to adding with irrigation water and spraying, 3% solution (100 ml) was tied up at the naval end of the bunch after the male bud is removed. The bunch size becomes uniform. One month earlier harvest was witnessed. The size of the top and bottom hands was uniformly big.

Jasmine

- Exceptional aroma and fragrance
- No incidence of bud worm
- Continuous flowering throughout the year

Time of application of Panchagavya for different crops is given as follows

Crops	Time schedule
Rice	10,15,30 and 50th days after transpalnting
Sunflower	30,45 and 60 days after sowing
Black gram	Rainfed: 1st flowering and 15 deays after flowering Irrigated: 15, 25 and 40 days after sowing
Green gram	15, 25, 30, 40 and 50 days after sowing
Castor	30 and 45 days after sowing
Groundnut	25 and 30th days after sowing
Bhendi	30, 45, 60 and 75 days after sowing
Moringa	Before flowering and during pod formation
Tomato	Nursery and 40 days after transplanting: seed treatment with 1 % for 12 hrs
Onion	0, 45 and 60 days after transplanting
Rose	At the time of pruning and budding
Jasmine	Bud initiation and setting
Vanilla	Dipping setts before planting

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NOURISH YOUR BODY WITH SUMMER COOL FOODS

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Introduction

Summer is extremely hot and calls for special attention to the human body. The hottest period of year in India is summer, which lasts from April to June and features longer days and shorter nights. Now-a-day's temperature is increasing from 40-45 degree Celsius due to deforestation, climate change, environment pollution etc. High temperature cause number of health problems. Drinking too many litres of water may not be sufficient to meet the requirements of the body. The best way to keep your body cool is by choosing the right diet. This will reduce internal heat and make you feel more comfortable with the rising temperature. While cool drinks and refrigerated foods seems to be cool but they only gives temporary coolness to the body and severely affects us.

In summer the risk of dehydration, indigestion, vomiting, and deficiency diseases increases. Hence we need to take cool foods which keeps the body hydrated and easily digestible. Consuming seasonal fruits and vegetables gives us protection from the UV rays as they contain high amounts of water and nutrients. Junk foods like pizzas, burgers etc. are avoided as they will be difficult to digest and end up feeling heavy and lazy.

Foods to Eat During Summer

- **Basil seeds**

Basil seeds are the rich source of nutrients and suitable for humid and hot weather. They are rich in carbohydrates, protein and essential fats. Basil seeds are consumed by soaking it in water. It gives very good health benefit in summer and reduces heat from the body.

Ragi malt

Ragi malt in combination with butter milk provides a cooling effect in the summer. It is rich in protein and calcium. It is an ideal summer drink, soothing and refreshing. Take 2-3 table spoons of ragi powder and combine it with the cold water. Then start boiling by placing it on the fire until it thickens. Serve with butter milk. Even jaggery powder can also be added to make it iron rich.

Corn

Corn is an amazing food to consume in summer. Corn contains lutein and zeaxanthin. These are two antioxidants which are helpful in protecting from harmful ultraviolet rays. You can prepare corn soup, corn fried rice, corn chat, and many other recipes.

Mint

Mint is a cooling herb. The combination of lemon and mint make a very refreshing drink in summer. Peppermint and spearmint are best for consumption during summer. It promotes digestion without boosting body temperature. It also relieves nausea and headaches and ease depression and fatigue. Making tea with mint leaves induce sweating and reduce body temperature. Mint chutney can be prepared as a side dish. Everybody like panipuri as a late evening snack, and mint can be used to make it. Sweet pani, which is made with dates and has greater nutrients and health benefits.

Dark, green leafy vegetables

It includes spinach, kale, drumstick greens, amaranth and mustard greens. Green leafy vegetables are highly rich in iron. They protect skin from sun damage during summer. They decrease sensitivity to UV light and dry skin. Strengthening the skins defence against the damaging rays of the sun. These greens can be consumed by preparing juice.


Coconut water

Coconut water is the best drink in the summer. It is full of electrolytes and instantly boosts the energy. It also contains vitamins, minerals, potassium, magnesium, in their natural form which replenishes the body with the nutrients lost due to sweating and dehydration. Tender coconut kernel contains essential olis.


Lemonade or Lemon Juice

It is the most common summer drink. Add the juice of one or two lemons to a glass of water and a pinch of roasted cumin powder, black salt for taste. Even sugar can be added for sweet lemonade.


Curd and Butter milk

They help body remain cool in summer as they contain calcium, riboflavin, protein, lactobacillus bacteria(good bacteria) which is good for health. Even fresh mint, cumin powder and black salt can also be added to increase the energy.


Gourds

Gourds include bottle gourd, ash gourd, snake gourd, bitter gourd, ridge gourd, etc. are highly rich in water content which hydrates the body. Juice can be prepared with these gourds by adding ginger or lemon or few springs of mint. These gourds help in reducing blood glucose and maintain body weight.


Roots and tubers

Roots and tubers include carrot, beetroot, radish etc. carrot and beetroot juice helps improve stamina and performance. Beetroot and carrot juice helps in easy digestion and removes toxins from the body. They are rich in beta carotene, a precursor to vitamin A, which improves the vision.

Fruits and Vegetables

Best fruits for summer include watermelons, muskmelons, citrus fruits and vegetables include cucumber, pumpkin, tomato etc.

- Watermelons and muskmelons sell at rapid rate in summer. Melons are the great summer companions as they have high water content and nutrients. They not only hydrate but boost the body with power packed nutrients like vitamin B1, magnesium, potassium and fibre.
- Citrus fruits comprises lemon, orange, Amla (goose berry). Citrus fruits are cooling because they aid digestion and help break down fatty foods. They are rich in vitamin c. They reverse the aging effects caused by the strong sun rays. They can be consumed directly or by preparing juice. To get the best results from amla, try to drink raw amla juice. Dry lemon chat can also be prepared.
- Vegetables such as cucumber, pumpkin, tomato etc. can be consumed. They are filled with water which will rehydrate the body. They can be eaten by preparing salads and raithas.
- Tomatoes have high water content and aids in easy digestion.
- Consumption of onion with curd helps in maintaining the body temperature.

Tips

- Try to consume fruits and vegetables in raw and natural form because nutrient loss is more in processed form.

- Avoid adding artificial flavours and colours to the food.
- Don't throw the peel of the fruits. It can be used as a scrub to the face which increases the skin tone. Even these peels are used as a manure for the plants.
- Cover the fruits always to avoid contamination.

❖ **Don'ts**

- ❖ Don't wash fruits and vegetables after cutting. Wash before cutting.
- ❖ Don't cut into small pieces as the nutrients loos is more. Cut into large pieces.
- ❖ Never cut fruit until you are ready to consume it.

Conclusion

Establishing appropriate eating habits is essential for maintaining good health. By adopting these simple tips into your daily routine, you can guarantee that you are nourishing your body with nutrient-dense foods that supply you with the energy and nutrition you need to thrive. To have an abundance of fresh food, you may start nutri garden, which will supply an ample amount of food for entire family. Enjoy the summer with summer cool foods.

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AVARAM: THE RESILIENT WONDER TREE ENRICHING LIFE'S VITALITY

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Abstract

The Avaram tree (Senna auriculata), revered as a 'Wonder Tree' in the Indian subcontinent, showcases an array of remarkable properties that make it a valuable resource for both health and agriculture. This botanical marvel, characterized by its vibrant yellow blossoms and resilient nature, has been a cornerstone of traditional medicine for centuries. The golden flowers of the Avaram tree are not only visually captivating but also hold therapeutic potential, offering solutions for managing diabetes, urinary tract infections, and menstrual irregularities. Beyond medicinal applications, Avaram contributes to wellness through weight management, skin revitalization, and stress relief. Its culinary use in herbal tea highlights its versatility and appeal. Moreover, the Avaram tree plays a pivotal role in sustainable agriculture, thriving in arid conditions and aiding in soil conservation. Culturally significant, it features prominently in religious ceremonies and local folklore, embodying resilience, and endurance. In a world increasingly focused on natural solutions and ecological sustainability, the Avaram tree emerges as a beacon of resilience and interconnectedness, showcasing the boundless wonders that nature bestows upon humanity.

Introduction

In the vast tapestry of nature, certain species stand out not just for their beauty but also for the incredible benefits they offer to humanity. One such marvel is the Avaram tree (Senna auriculata), a species native to the Indian subcontinent that has earned the signature of 'Wonder Tree' for its remarkable properties. From its radiant yellow flowers to its diverse array of uses, the Avaram tree with potent medicinal properties, is experiencing renewed interest in both allelopathic and indigenous medicine due to its lack of intoxicants and affordability. Particularly in developing countries, this readily available plant offers a low-cost source of antimicrobial and antidiabetic agents, contributing significantly to public health. Used for centuries in Ayurvedic medicine, Avaram serves as a tonic, astringent, and remedy for diabetes, conjunctivitis, and ophthalmia. This versatile plant presents a truly serendipitous discovery for human health.

Avaram: A Botanical Overview

Avaram, scientifically known as Senna auriculata and commonly referred to as Tanners Cassia, is a vibrant flowering plant with distinctive yellow blooms. In the Tamil language, it is aptly named "Avaram." Belonging to the Caesalpiniaceae family, this leguminous tree exhibits a highly branched shrub structure characterized by smooth cinnamon-brown bark and densely pubescent branchlets.

The stem of Avaram Senna displays a reddish-brown hue, contributing to the plant's visual appeal. Noteworthy is its unique feature of being an all-time flowering live plant, ensuring a continual display of its yellow blossoms. The fruit of Avaram Senna is encapsulated in a leathery pod, housing numerous seeds within.

Fig 1. Senna auriculata

Radiant Blossoms

The Avaram tree is renowned for its vibrant, golden-yellow flowers that bloom in clusters, adorning the landscape with a splash of colour. These blossoms not only contribute to the tree's aesthetic appeal but also serve as a source of nectar for bees and butterflies, promoting biodiversity in the ecosystem. Beyond their visual allure, the flowers are a treasure trove of health benefits, containing compounds that have been traditionally used in various remedies.

Fig. 2. Golden-yellow flowers of Avaram Senna

Health and Wellness

The Avaram tree has long been celebrated in traditional medicine for its therapeutic properties. The flowers, leaves, and seeds of the tree are rich in natural compounds, antioxidants, diuretic properties helping combat several health complications.

1. Managing Diabetes

The dried flowers of Avaram Senna are utilized in creating Avaram Poo powder, presents a natural remedy for diabetes management. The flowers, when processed into tea, demonstrate the ability to reduce blood sugar levels effectively. Renowned for its antidiabetic properties, Avaram Senna is a key component in the preparation of "Avarai Panchaga Chooranam," a formulation specifically employed in diabetic care to regulate blood sugar levels.

Fig. 3. Avaram poo powder

2. Combating Urinary Tract Infections

1. **Antibacterial Activity:** Studies suggest that antibacterial properties of avaram juice hinder the growth and proliferation of bacteria responsible for Urinary Tract Infections.
2. **Detoxification:** Avaram acts as a detoxifying agent, helping the body flush out harmful toxins and promoting overall urinary system health.

3. Balancing Menstrual Cycles

Avaram flower powder is recognized for its ability to contribute to the regulation of menstrual cycles, providing a natural solution to prevent excessive flow.

4. Facilitating Weight Loss

Regular consumption of Avaram juice is associated with effective weight loss by aiding in the shedding of excess fat. This natural beverage not only supports weight management but also plays a role in maintaining overall body health and regulating low blood cholesterol levels.

5. Revitalizing the Skin:

Avaram powder emerges as a versatile solution for various skincare concerns when applied externally. This natural remedy serves as an effective face pack, working wonders to prevent black spots, even out skin tone, and promote blemish-free skin. Its skin-enhancing properties contribute to an improved complexion, reduced pigmentation, and smoother skin texture, imparting a radiant glow. Avaram powder's anti-inflammatory characteristics make it beneficial in reducing pimples, while its stimulating properties actively rejuvenate and awaken dormant skin cells, promoting a revitalized and vibrant appearance.

6. Additional Benefits

Avaram aids in preventing dehydration, making it a valuable assistant for maintaining hydration levels. In the realm of hair care, Avaram proves to be beneficial. It also demonstrates effectiveness in alleviating body pain and preventing constipation. Moreover, its stress-relieving properties contribute to a sense of calm, fostering improved sleep quality. Notably, Avaram aids in naturally boosting insulin levels, adding another layer to its diverse range of health-enhancing attributes.

Culinary Delights

Beyond its medicinal uses, the Avaram tree offers culinary delights that have been cherished for generations. The dried flowers are commonly used to prepare a refreshing herbal tea, known for its mild flavor and potential health benefits. Rich in polyphenols and flavonoids, Avaram tea is a popular choice for those seeking a natural and wholesome beverage.

Sustainable Agriculture

The Avaram tree's resilience extends to its role in sustainable agriculture practices. Known for its ability to thrive in arid conditions, this wonder tree plays a crucial role in soil conservation and erosion prevention. Its deep-rooted system helps bind the soil together, making it an excellent choice for afforestation projects and sustainable land management.

Cultural Significance

In addition to its ecological and health-related contributions, the Avaram tree holds cultural significance in many communities. Its presence in religious ceremonies, traditional rituals, and folklore reflects the deep connection people share with this remarkable species. The tree's ability to withstand challenging conditions and still flourish serves as a symbol of tenacity and resilience in the face of adversity.

Conclusion

The Avaram tree, with its golden blossoms and numerous benefits, stands tall as a symbol of wonder and resilience. From promoting health and well-being to contributing to sustainable agriculture, this remarkable species weaves itself into the fabric of life, offering a lesson in tenacity for all who take a moment to appreciate its beauty and embrace its gifts. As we continue to explore the wonders of the natural world, the Avaram tree stands as a shining example of the miracles that nature provides when we learn to live in harmony with it.

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INSECT PEST MANAGEMENT IN ORGANIC FARMING

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Introduction

Organic farming uses a holistic approach to pest management, relying heavily on the biodiversity and natural processes of the agro-ecosystem. The ultimate aim is to prevent pests before they become economically harmful without causing risk to the environment. Cultural methods, mechanical methods and Biological methods are used in organic farming to manage insect pests.

1. Cultural methods

a. Early sowing

Altering the sowing period reduce some pests in crops. For example, Sweet corn grown in summer is less prone to damage by earworm when compared to late season.

b. Crop rotation

Growing of different crops in same plot alternatively is called Crop rotation. The severity of pests can be reduced by growing the crops of different family. We should avoid growing crops of same family. The serious pests like brinjal shoot and fruit borer (*Leucinodes orbonalis*), Colorado potato beetle (*Leptinotarsa decemlineata*).

c. Cover crop

Cover crops are the crops which prevents pest and diseases of the main crop. It also improves the soil fertility and moisture holding capacity of the soil. The rotation of cash crops with grass species reduced the insect pests as they are resistant to them.

d. Trap crop

A trap crop is plant that attracts the pests which reduces the damage to main crop. E.g.: Alfalfa can be planted as a trap crop in strawberry field in the ratio of 16 : 1 in order to control the major pest of strawberry, *Lygus pratensis*.

e. Fertilizer usage

Using more amount of nitrogen fertilizer causes pest issue in many crops. Instead of using fertilizers, the use of organic manures improves the pest resistance in crops.

2. Mechanical methods

a. Hand picking

Picking of insect larva and its eggs by using hands. It is the simplest and effective method of pest control in organic farming. Major pests like Caterpillar, *Epilachna* beetle in Brinjal, Cabbage butterfly larva and white grub can be handpicked.

b. Diatomaceous earth

Diatomaceous earth consists of remains of fossil diatoms. Diatoms are a type of hard-shelled algae. The diatoms have sharp edges which scratch the soft bodied insects and causes death by dehydration. It can be sprayed or dusted.

c. Soil tillage

Soil tillage can destroy the insects living in the soil and expose them to birds and predators.

d. Sticky traps

Sticky traps can be placed in the field to control small insects. 25 sticky traps are required for one acre. Yellow sticky traps attract whiteflies and aphids. Blue sticky traps attract thrips and cabbage fly. Fruit flies and cotton stem weevil are attracted by green colour sticky traps. Leaf hoppers are attracted by orange sticky traps.

e. Light traps

During night time, most of the beetles and moths are attracted to light. So light traps are placed in field during 7 PM to 11 PM. Different types of lamps like kerosene lamp and electric lamps are used to control pests. The traps should not be placed above 11 PM as it affects beneficial insects.

3. Biological methods

a. Predators

A predator is an organism which kills and eats other organisms. The Spotted lady beetle (*Coleomegilla maculata*) is potentially important predator of Colorado potato beetle's eggs and larva. The Anthocorids like Poppius (*Orius sauteri*) are used to control thrips in crops like Pepper, Onion, Brinjal and Cucurbits. 1 to 10 predator insects are released per m^2.

b. Parasitoids

A parasitoid is a organism that lives its larval stage depending on a host organism. It is used as a biological control of pests.

Egg parasitoid

Trichogramma spp. parasitizes the eggs of lepidopteran pests. It is used in crops like Maize, Tomato, Cabbage, Potato, Pomegranate and Sugarcane. Rate of release: 5 to 8 cards per acre at 15 to 30 days interval.

Larval parasitoid

Bracon brevicornis is an example for larval parasitoid. It lays 150 to 200 eggs during its lifetime. It is used to control Black headed caterpillar in Coconut. Rate of release: 4 to 5 cards per acre or 10 to 15 adults or pupae.

c. Biopesticides

Bacillus thuringiensis is a bacteria used to control *Helicoverpa, Spodoptera,* hairy caterpillars in vegetables, fruits and cereals. *Beauveria bassiana* (entomopathogenic fungus) is a white colour fungal biopesticide used to control Tomato fruit borer, Rhinoceros beetle in Coconut, Cotton bollworms and Sugarcane stem borer.

d. Nematodes

Entomopathogenic nematodes are the beneficial nematodes which kills pest insects. They live in moist and damp soil. The common entomopathogenic nematodes are the members of Steinernematidae and Heterorhabditidae. They infect larval forms of butterflies, beetles and adult forms of beetles, grasshoppers and crickets.

e. Botanicals

Pyrethrin from pyrethrum flowers kills the insects by acting on its nervous system.

Azadiractin from neem tree shows anti-feedant activity and prevents oviposition.

1) Ryania is a natural product found in the plant *Ryania speciosa*. Ryanodine is an alkaloid extracted from its roots which is used to control Onion thrips and potato aphids. It is a slow stomach poison for rats.
2) Sabadilla is an insecticide against cabbage worm and cabbage looper. It is produced by grinding the seeds of *Schoenocaulon officinale*. This affects the nervous system of the insects.

Other measures to control pests in organic farming are cow dung extract, Siriyanangai (*Andrographis paniculata*) decoction 3 to 5 %, Arivalmanai poondu (*Sida spinosa*) decoction 5%, Neem Seed Kernel Extract (NSKE) and Garlic Ginger Chilli extract. These are used to control borers, sucking pests, beetles and bugs.

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VALUE ADDITION OF BANANA

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Introduction

Value addition can enhance food security through lowering food loss, raising product quality, and lengthening product shelf life. In periods of scarcity or unfavourable weather, value addition can also aid in maintaining the nutritious content of fruits and vegetables. One significant tropical fruit is the banana. The fruit is regarded as the fourth most significant food product in the world. 32 percent of the world's fruit production is produced in India. This is the only tropical fruit that leads the international fruit commerce and is exported in significant quantities. Cultivated since ancient times, it is one of the most common and oldest Indian fruits. Banana by virtue of its, multiple uses is popularly known as **"Kalpataru"** (a plant with virtue). Banana is a highly perishable fruit with high moisture content. However the post harvest losses can be reduced by applying appropriate processing techniques.

BANANA CHIPS

Chips made of bananas Roughly 80% mature nendran fruits are gathered and in high demand. After peeling and treating with 0.1% potassium metabisulphite, the fingers are sliced into 1.2–0.8 mm thick pieces and deep-fried in an appropriate cooking oil—ideally coconut oil..

This will produce crispy, yellow-colored chips when fried. They are then packaged in plastic bags and dusted with regular salt. Under ambient circumstances, their storage life typically spans between 30 and 35 days. Its lifespan can be increased by up to four months by packing the chips in laminates with nitrogen gas. Other varieties of banana chips, such as flavoured, sweet, sour, tomato-flavored, pepper-flavored, and so on, are also becoming more and more popular.

BANANA FRUIT CANDY/STEM CANDY

In Kerala state, banana fruit candies manufactured with nendran, jiggery, and ginger are extensively available in the market. True stem bananas can also be processed into candies via osmotic dehydration and sun drying. fig banana Banana figs are sticky, sweet banana fruits that have been dried or dehydrated. Dwarf Cavendish or Karpuravalli banana fruits that are fully ripe are peeled, treated with a 0.1% potassium metabisulphite solution, and then dried at 50°C in the oven or in the sun. These figs are packaged in bags made of polypropylene or any other appropriate container. In ambient circumstances, their shelf life is around three to four months.

BANANA FLOUR

Banana flour is prepared from mature green bananas, which have a high starch content. It can be used as nutritious adjuvant in several food preparations like bread, cakes, biscuits, health drink and baby food formulations. It can also be blended with other cereal flours for making chapaties and roties (Indian bread). It has some medicinal property to cure ulcers. Under cool and dry conditions it can be stored up to one year without any adverse change in their composition. Banana powder Banana powder is prepared from fully ripe banana fruits either through drum drying or spray drying process. The moisture content of final product should be around 2-4%. This product has got high market value as it is extensively used in confectionary industry, ice cream preparations and baby food making. When suitably packed it will have a shelf life of more than 6 months.

BANANA JUICE

Banana puree is extremely thick, thus it cannot be used straight to make juice. In order to achieve clear juice, the puree is treated with a pectolytic enzyme and filtered or centrifuged. Under normal circumstances, it can be stored for at least six months after pasteurisation and bottling. Banana fruit bar A banana fruit bar is a dessert made from any kind of ripe banana fruit. It is prepared by mixing banana pulp, sugar, citric acid, and pectin in an appropriate ratio, then drying the mixture in an oven at 70°C with a ghee-coated beam until it forms a sheet. After that, it is sliced to the proper size and placed inside polyethylene pouches. Biscuits with bananas .To make banana biscuits, combine 30% maida and 60% banana flour. The dough is made using flour mixture and suitable proportions of sugar, saturated fat, baking powder, milk powder and essence. These biscuits are very tasty and highly nutritious.

BANANA JAM AND JELLY

The process of making banana jam involves heating fruit pulp, sugar, pectin, and citric acid in the proper amounts until a firm set is achieved. There are numerous banana cultivars that work well for jam-making.

This product has a big market and strong commercial worth. After the necessary amounts of sugar, citric acid, and pectin are added, clear, filtered fruit extract devoid of pulp is boiled to create banana jelly, a semi-solid product. A flawless jelly should have a rich fruit flavour, be transparent, gorgeous, and sparkle in colour.

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RICE DISEASES: UNDERSTANDING AND MANAGING CROP HEALTH

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Abstract

India has experienced a six-fold increase in agricultural production, albeit at the expense of natural resource degradation. This growth primarily occurred in prosperous regions, leaving small holder farmers with fewer benefits. The exploration of "Rice diseases: Understanding and Managing Crop Health" focuses on the diverse diseases impacting rice cultivation while highlighting the importance of taking proactive measures for disease prevention and control. These provides insights into how diseases affect rice yields and proposes strategies to bolster crop resilience. Furthermore, it delves into the contributions of advanced agricultural practices, technology and research in addressing the challenges posed by rice diseases. This study aims to foster a deeper understanding of crop health management, contributing to the development of a sustainable and resilient rice cultivation ecosystem.

Introduction

Rice (*Oryza sativa* L.), a crucial cereal crop cultivated worldwide, holds significant importance in global agriculture. The USDA anticipates a historic milestone in rice production for the 2023-24 season, projecting a record 520.5 million tonnes, reflecting a more than 2%

increase from the previous year. Key contributors to this growth include Bangladesh, the European Union, China, Pakistan and the United States. The global domestic and residual use for the same period is estimated at a record 523.0 million tonnes, showing a 1.5 million-tonnes increase from the previous year, with South Asia playing a predominant role in this surge. However, surpassing global production, the projected domestic and residual use is expected to lead to a decline in global ending stocks for the third consecutive year, reaching 166.7 million tonnes in 2023-24. This marks the smallest global rice stock since the 2017-18 period (Anonymous, 2023). The agricultural landscape in India witnessed a significant transformation, propelling food grain production to new heights during the green revolution. This revolutionary period marked a complete overhaul of agricultural practices in the country, with a pivotal role played by high-yielding varieties of seeds. In India it is cultivated under area of 43.19 million hectares with production of 117.47 million tonnes where as in Gujarat it is cultivated under area of 0.84 million hectares with production of 1.93 million tonnes (Anonymous, 2019). Rice ecosystem favours many diseases which are major constraints in its production. Inspite of the various constraints, diseases play vital role in reduction of yield and known to occur worldwide in many countries.

FUNGAL DISEASES OF RICE		
Sr. No.	**Disease**	**Causal Organism**
1.	**Blast**	*Pyriculria grisea*
2.	**Brown spot**	*Helminthosporium oryzae*
3.	**False smut**	*Ustilaginoidea virens*
4.	**Kernel smut**	*Tilletia barclayana*
5.	**Bakane disease**	*Fusarium fujikuroi*
6.	**Sheath blight**	*Rhizoctonia solani*
7.	**Sheath rot**	*Sarocladium oryzae*
8.	**Stem rot**	*Sclerotium oryzae*

MINOR FUNGAL DISEASES		
9.	**Sheath spot**	*Rhizoctonia oryzae*
10.	**Stackburn (Alternaria leaf spot)**	*Alternaria padwickii*
11.	**Stem rot**	*Sclerotium oryzae*
12.	**Water-mold**	*Fusarium* spp. *Pythium* spp.
13.	**Black kernel**	*Curvularia lunata*
14.	**Pecky rice (kernel spotting**	*Cochliobolus miyabeanus, Sarocladium sp.*
15.	**Root rots**	*Fusarium sp. Pythium sp.*
16.	**Seedling blight**	*Fusarium sp. Curvularia sp.*

Source: https://en.wikipedia.org/wiki/List_of_rice_diseases

BACTERIAL DISEASES		
1.	**Bacterial blight**	*Xanthomonas oryzae* pv. *oryzae*
2.	**Bacterial leaf streak**	*Xanthomonas oryzae* pv. *oryzicola*
3.	**Foot rot**	*Erwinia chrysanthemi*
4.	**Grain rot**	*Burkholderia glumae*
NEMATODE DISEASES		
1.	**Rice cyst nematode**	*Heterodera oryzae*
2.	**Rice root nematode**	*Hirschmanniella oryzae*
3.	**Rice root-knot nematode**	*Meloidogyne graminicola*
4.	**White tip nematode**	*Aphelenchoides oryzae*

VIRAL DISEASES		
1.	**Rice tungro**	Rice tungro virus (RTSV, RTBV)
2.	**Rice grassy stunt**	Rice grassy stunt
3.	**Rice yellow dwarf**	Rice yellow dwarf virus
4.	**Rice ragged stunt**	Rice ragged stunt virus

Source: https://en.wikipedia.org/wiki/List_of_rice_diseases

Advantages	**Disadvantages**
Comprehensive understanding	Challenges for non-experts
Promotion of proactive measures	Resource constraints
Insightful examination of yield impact	Insufficient regional focus
Strategies for enhanced crop resilience	Potential over emphasis on technology
Addressing advanced agricultural practices	Limited environmental considerations
Contribution to sustainability	Neglect of local knowledge
Consideration of equitable benefits	Inadequate emphasis on socio-economic factors

Advanced technologies

The incorporation of cutting-edge technologies represents a transformative strategy for comprehending and overseeing the well-being of rice crops. Advancement signifies a substantial progression in agricultural methods, introducing innovative solutions to tackle the challenges associated with rice diseases. Various advanced technologies contribute to a more refined and effective approach to ensuring the health of rice crops.

- Precision agriculture
- Remote sensing and imaging
- Biotechnology and genomics
- Smart farming applications
- Internet of Things
- Blockchain technology
- Unmanned Aerial Vehicles

Success Stories

Name of the Success story	Location	Achievement
Enhanced yields in south east Asia	Vietnam, Thailand and Indonesia	The early disease detection methods and utilizing satellite imagery, drones
Improved resilience in Indian agriculture	Punjab, India	Incorporating GPS-guided tractors
Success with Genetically Modified Varieties in the Philippines	Luzon, Philippines	Integration of biotechnology and genomics
Tech-Driven Farming in the United States	Arkansas, USA	Integrated smart farming applications
Blockchain traceability in Thailand	Chiang Mai, Thailand	Transparency and safety in rice products.
Aerial Surveillance Success in Bangladesh	Dhaka, Bangladesh	Unmanned aerial vehicles (UAVs) equipped with sensors for aerial surveillance

Conclusion

In terms of agricultural knowledge, provide insights and strategies that considerably contribute to rice crop sustainability. The success stories offered highlight the concrete benefits of using modern technologies and strategic methods. Rice production ecosystems can become more robust, sustainable and productive by increasing knowledge about crop health management. As we move forward, continued research, collaboration and widespread adoption of these insights will be instrumental in ensuring the well-being of rice crops and securing global food sustainability.

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Source: https://en.wikipedia.org/wiki/List_of_rice_diseases

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SIGNIFICANCE OF STEM CELLS AND CORD BLOOD

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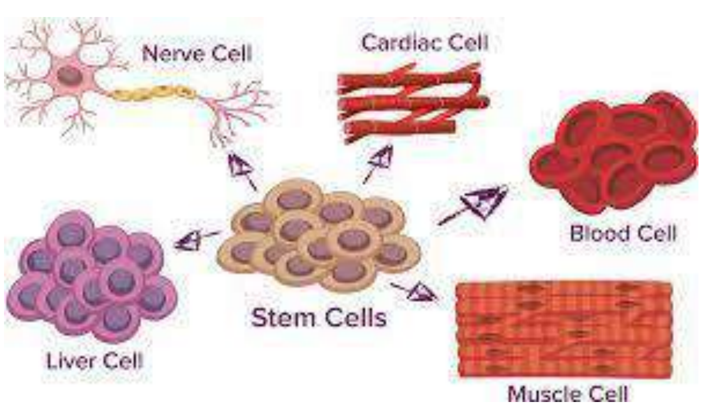
Introduction

Stem cells are unspecialized mass of cells in the human body. Under right condition in the body it has the ability to differentiate into any type of cell in an organism and have the ability of self renewal. No other cells in the body has the ability to generate another new cell types. Stem cells can exist in both the adult and embryo cells. Zakrzewski, W.*et al*., (2019). Sources of stem cells are bone marrow, peripheral blood andblood in the umbilical cord after a baby's birth. Stem cell based therapy is one of the most promising disciplines in the field of modern science and medicine for regenerative medicine. This regenerative medicine as an suitable alternative for an conventional drug based therapies for wide range of diseases like neurodegenerative diseases and diabetes. Chari *et al*., (2018). In mammals, there are two broad types of stem cells. Embryonic stem cells are isolated from the inner cell mass blastocytes and adult's stem cells that found in various tissues.



Types of stem cells

Totipotent stem cells

Totipotent stem cells has the ability to divide and differentiated into the cells of whole organism. Totipotency has the highest differentiation potential and allows cells to form both embryo and extra-embryonic structures. Example zygote which is formed after a sperm fertilizes an egg.

Pluripotent stem cells

Pluripotent stem cells form cells of all germ layers but not extra embryonic structures, such as the placenta. Example – Embryonic stem cell, Pluripotent stem cells. iPSCs it is artificially generated from somatic cells, their culturing and utilization are very promising for present and future regenerative medicine.

Multipotent stem cells

Multipotent stem cells can specialize in discrete cells of specific cell lineages. Example – Haematopoietic stem cell.

Oligopotent stem cells

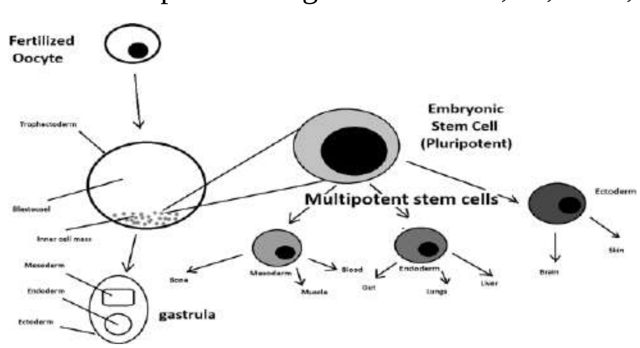
Oligopotent stem cells can differentiate into several cell types. Example - Myeloid stem cell – divide into white blood cells but not red blood cells.

Unipotent stem cells

Unipotent stem cells are characterized by the narrowest differentiation capabilities and a special property of dividing repeatedly. Therapeutic use in regenerative medicine. These cells are only able to form one cell type, Example - Dermatocytes. James and Bobrow (2005).

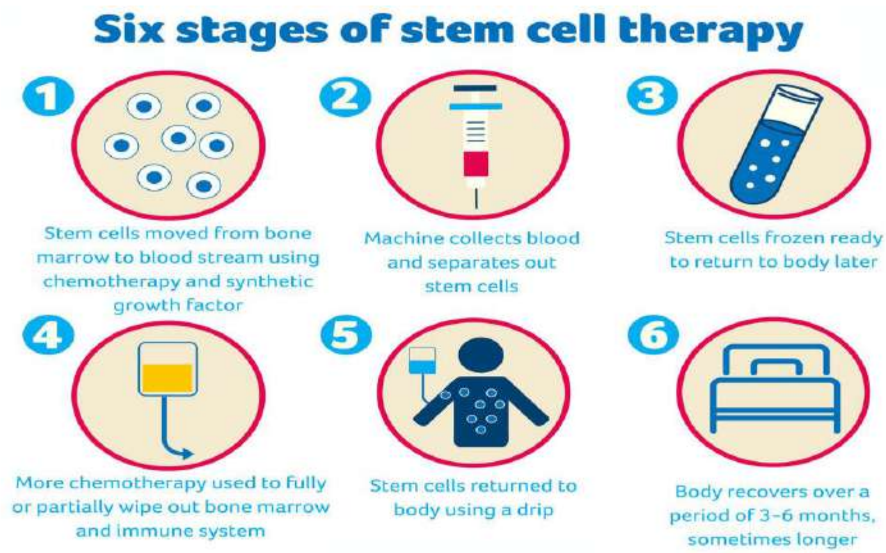
Stem cell biology

Oocyte development and formation of stem cells: the blastocoel, which is formed from oocytes, consists of embryonic stem cells that later differentiate into mesodermal, ectodermal, or endodermal cells. Blastocoel develops into the gastrula. Pardal, R., *et al.*, (2006)



Stem cell therapy

Blood forming stem cell transplantation is an most accepted treatment to restore the body's ability to make blood and immune cells. When compared to radiation therapy or high dose chemotherapy stem cell transplantation does not causes any severe injury especially blood diseases like leukemia, lymphoma, myeloma, myelodysplastic syndromes and other blaood cancers. Connie Witherspoon (2012)



Significance of Stem cell therapy

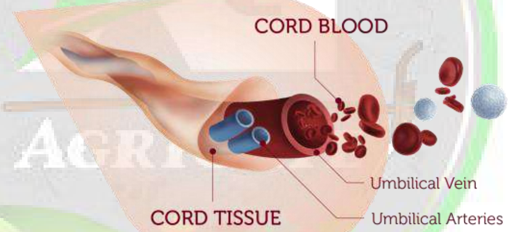
Stem cell therapy can be used as a regenerative medicine and therapeutic cloning. It helps to treat and cure variety of diseases like Parkinson's disease, schizophrenia, Alzheimer's disease, cancer, spinal cord injuries, diabetes, Heart diseases, stroke and cancers. It helps to replace or repair damaged organs and reduces risk of transplantation. It will help the scientists to learn about the human growth and cell development. Mimeault & Batra (2006). Scientists and doctors will be able to test millions of potential drugs and medicines without the use of animals or human testers. Stem cell research helps to study of developmental stages that cannot be studied directly in human embryo it helps to prevent and treat the birth defects, pregnancy loss and infertility. Usage of adult stem cells to treat diseases is that patient's bodies own cells could be used to treat a patients. Mishra *et al*., (2020).

Disadvantage

Embryonic stem cells may not be the solution for all ailments. Stem cell therapy for heart disease patients become a problem of coronary arteries narrower. Adult stem cells like blood stem cells make only blood and brain stem cells make only brain cells. It is derived from the embryo so sometimes body can reject the transplant. Long term side effects of stem cell therapy still completely unknown. Use of embryonic stem cells for research blastocyst formation were destructed. Poulos (2018).

Cord Blood Stem Cell

Umbilical cord blood is the blood that remains in the umbilical cord and placenta post-delivery. At the end of the term maternal fetal transfer of cells to boost the immune system system of the baby and mother and helps for preparation of labor. It made rich source of stem cells in the cord blood at the time of delivery. After delivery it was discarded as a waste material. This cord blood has been collected and frozen for the future use. It helps to treated the blood diseaseslike leukemia and other blood cancers. Cord blood contains Haematopoietic stem cells it helps to produce blood forming cells and immune cells. Transplants of HSCs from cord blood appear to lead to fewer immune system incompatibilities, such as graft-versus-host disease. Ballen (2010).



Cord blood in disease treatment

Cord blood has an abundance of stem cells and immune system cells it helps the body to regenerate tissues and systems. It helps to treat nearly 80 diseases and mostly cord blood treatments have been performed more than 35,000 times around the globe to treat certain cancers like lymphoma and leukemia and other diseases like anemias, inherited metabolic disorders solid tumors, autism, cerebral palsy and Alzheimer'sand orthopedic repair. Bahk *et al*., (2010).

Cord Blood Stem Cell Transplants

Acute lymphocytic leukemia Acute myelogenous leukemia (AML), Myelodysplastic syndromes (MDS), Chronic myelogenous leukemia (CML), Juvenile chronic myelogenous leukemia (JCML), Chronic lymphocytic leukemia (CLL), Hodgkin and nonHodgkin lymphoma, Neuroblastoma, thalassemia, severe combined immune deficiency (SCID), WiskottAldrich syndrome, Metabolic diseases such as adrenoleukodystrophy and Hurler syndrome, and severe aplastic anemia. Bahk *et al*., (2010).

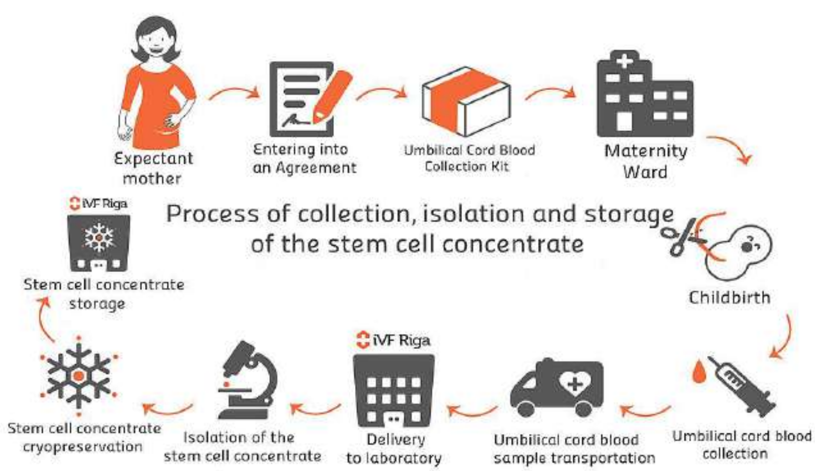
Advantages of cord blood stem cells

Ease of availability, cord blood stored in a public cord blood bank has been prescreened, tested, frozen and is ready to use. Human Leukocyte Antigen (HLA) Matching. HLA matching plays an important role in successful engraftment, severity of graft-versus-host disease (GVHD) and overall survival. It helps to reduce the Graft-Versus-Host Disease and infectious disease transmission. Cord blood stem cell transplants carry less risk of transmission of blood-borne infectious diseases compared with stem cells from the peripheral blood or marrow of related or unrelated donors. Park *et al*., (2011)

Disadvantages

It is not known how long cord blood can be frozen and stored before it loses its effectiveness. The number of cells required to give a transplant patient the best chance for engraftment and for surviving the transplant is based on his or her weight, age and disease status. Cord blood transplant recipients may be vulnerable to infections for an average of up to one to two months longer than marrow and peripheral blood stem cell recipients. Park *et al*., (2011)

Collection and Storage process



Conclusion

Stem cell therapy is very promising fields with reports of clinical success in treating various diseases like neurodegenerative disease and macular degeneration progressing rapidly. iPSC are conquering the field of stem cell research with endless possibilities of treating diseases using patients own cells. Stem cells can be used in different areas. In current treatments, brain damage, cancer, spinal cord injury, heart damage, diabetes, graft vs host disease. There is no toxic effect and adverse reactions compare to the chemotherapy, radiotherapy. . In future stem cell based therapies had significantly impact on human health.

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ERGONOMICS IN HANDLOOM SECTOR: NEED OF THE HOUR

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Abstract

Ergonomics plays a vital role in the handloom sector, weavers spend long hours involved in various repetitive tasks such as weaving, spinning, winding and dyeing etc without considering their individual physical capabilities leading to various health problems. Application of Ergonomic principles in workstation design, tool design, work posture can enhance worker safety, health, and productivity. The handloom weavers have the risk of developing musculoskeletal disorders (MSDs) due to repetitive tasks, awkward postures, and poor workstation design. Creating a safe and ergonomic work environment determines a commitment to the well-being of its workers which can help in retaining existing skilled handloom weavers and attracting new talent to the handloom sector, which is essential for its sustainability and growth.

Keywords: Ergonomics, Handloom, Weavers, Musculoskeletal disorders

Introduction

Ergonomics also known as human factor engineering is a science that applies to the design of products, tools, and workplaces. Its main goal is to minimize fatigue, discomfort, risk of injury and other potential health problems by aligning work with an individual's capabilities. It applies knowledge of physical and psychological characteristics to the development of tools and systems for human use. It is an approach to deal with musculoskeletal problems caused over by occupation. It seeks to increase the usability, effectiveness and safety of people working with machines.

Ergonomics help in the prevention of WMSDs and the improvement of working conditions in industries that will have a significant impact on enhancing people's quality of life and improving efficiency.The goal of ergonomics is to create a better workplace. Due to its vast range, human-factors engineering incorporates elements from engineering, design, anthropometry, biomechanics, physiology, environmental science, psychology, and sociology.

Handloom Sector: India's Scenario

India's handloom sector is one of the country's largest unorganised economic activity that has a long history of exceptional craftsmanship which symbolizes and preserves the lively Indian culture. The highest incidence of musculoskeletal disorders (MSDs) among handloom weavers can be related to long hours of static work with uncomfortable posture at traditionally designed looms.

The handloom industry weavers work with a lot of hand tools, which could have a significant impact on upper limb musculoskeletal disorders (MSDs). Weavers rely on two different types of hand-operated looms for weaving processes: (i) Bench type looms in which they sit on a bench above the floor and use their legs to hang down to manipulate the pedals. (ii) Pit looms in which weavers sit on the floor and use their legs to swing the pedals down below the surface.

In weaving, the arms are raised away from the body to operate shuttles and pedals, requiring repetitive motions of the upper and lower limbs. Both the electric power looms and the manually driven handlooms are either operated in separate sheds or are operated from home. Due to their limited working postures, poor loom design, lengthy workdays, repetitive activities and seat types, weavers are known to have a high prevalence of musculoskeletal health problems. Vibrations, physical and psychological stress, and unfavorable weather conditions in workplace have all been linked to the development of MSDs in handloom weavers.

Workplace stress is categorised into physical and psychosocial dangers when it is combined with physical and emotional reactions. Moreover, workers in the handloom industry must tolerate a hot, packed, and inadequately ventilated environment. Handloom weavers are exposed to noise of the weaving machines which is unhealthy and leading to hearloss (**Bedi , 2006 and Durlov *et al.* 2018).**

Multiple occupational risk factors such as awkward posture, heavy lifting, repetitive motion, extended work hours and high visual demands are connected with handloom weaving activities which can lead to upper extremity pain and discomfort as well as other health issues.

Due to the demands of the tasks, the workers accomplish themselves in various awkward and unnatural positions without taking into account their individual capabilities and limitations.Additionally these unnatural postures may cause stress and trauma for the workers putting their health at danger and risk **(Nag *et al.*2010; Dewangan *et al.*2015).**

Conclusion

Handloom weavers are facing ergonomic challenges due to the nature of their work, which involves repetitive motions, prolonged sitting, and manual handling of materials.The application of ergonomics in handloom industry can establish more secure and comfortable work environments that promote their well-being and efficiency of weavers. The Teamwork between weavers, employers, and ergonomic specialists is essential to identify and implement effective ergonomic solutions in the handloom industry for sustainability.

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THERAPEUTIC AND NON THERAPEUTIC USES OF HYPEROSIDE - A FLAVONOL GLYCOSIDE

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Introduction

Hyperoside (systematic IUPAC name - 2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2*S*,3*R*,4*S*,5*R*,6*R*)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxychromen-4-one)) is a flavonoid compound available in a variety of plants. It is also known as quercetin-3-O-galactoside, hyperozide, hyperosid, hyperosid, hyperin, quercetin galactoside, quercetin-3-galactoside etc is a flavonoid glycoside compound with the chemical formula $C_{21}H_{20}O_{12}$. It is a pale yellow needle crystal. It belongs to the flavonol subclass of flavonoids and is commonly found in various plants, including fruits, vegetables, and medicinal herbs. Here are some key chemical properties of hyperoside:

1. **Structure**: Hyperoside consists of a flavonol core, which comprises two aromatic rings (A and B) linked by a heterocyclic ring (ring C). It is characterized by the presence of a galactose moiety attached to the 3-position of the flavonol backbone.
2. **UV absorption**: Hyperoside exhibits characteristic UV absorption spectra, with absorption maxima (λmax) typically observed at around 258 nm and 354 nm in methanol or ethanol solutions.
3. **Chemical stability**: Hyperoside is relatively stable under normal conditions but may degrade when exposed to factors such as light, heat, and Ph extremes. Degradation processes may include hydrolysis of the glycosidic bond or oxidation of the flavonoid structure.

4.Acid-Base properties: Hyperoside contains several hydroxyl groups, making it slightly acidic.It can form salts with bases, and its reactivity can vary depending on the Ph of the solution.

4. **Chromatographic properties**: Hyperoside can be analyzed and separated using various chromatographic techniques, such as high-performance liquid chromatography (HPLC) and thin-layer chromatography (TLC), often coupled with UV or mass spectrometric detection methods.

The other chemical properties are as follows,

Property Name	**Property Value**
Molecular Weight	464.4 g/mol
Solubility	Sparingly soluble in water but more soluble in polar organic solvents such as ethanol and methanol
Melting point	Typically melts at temperatures ranging from approximately 250 to 260 degrees Celsius
Density	1.879 g/mL
Hydrogen Bond Donor Count	8
Hydrogen Bond Acceptor Count	12
Rotatable Bond Count	4
Exact Mass	464.09547607 g/mol
Monoisotopic Mass	464.09547607 g/mol
Topological Polar Surface Area	207Å²
Heavy Atom Count	33
Covalently-Bonded Unit Count	1

Understanding its chemical characteristics is essential for its isolation, purification, analytical detection and formulation in pharmaceuticals, nutraceuticals and other products. It also contribute to the biological activities and applications of hyperoside, including its antioxidant, anti-inflammatory, anticancer (anti breast cancer, anti lung cancer, anti pancreatic cancer, anti osteocarcinoma, anti uterine cancer, anti liver cancer, anti skin cancer, anti prostate cancer, anti renal cancer, anti colon cancer, anti thyroid cancer etc),

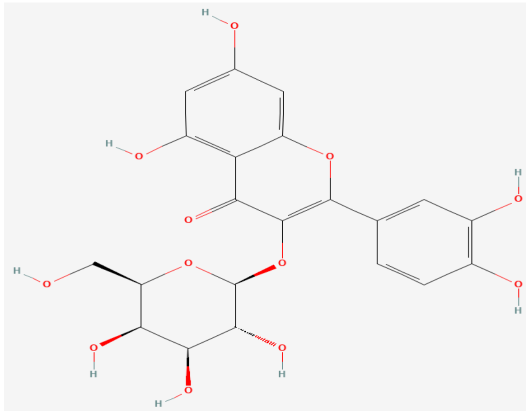

Fig 1. Chemical structure of hyperoside

antithrombotic, antidiabetic, antibacterial, antiviral, anti coagulant, anti platelet, hypoglycemic, anti diarrheal, antidepressant, organ protective effects (neuro protective, hepato protective, cardio protective, brain protective, renal protective, lung protective, vaso protective, bone protective and joint protective) and other pharmacological effects. The compound is used in treating sepsis, arthritis, colitis, diabetic nephropathy, myocardial ischemia-reperfusion, pulmonary fibrosis etc. These are some of the potential uses of hyperoside based on current research findings.

Therapeutic uses of hyperoside

I.**Antioxidant properties**: Hyperoside exhibits strong antioxidant activity, helping to scavenge free radicals in the body. This property is beneficial for reducing oxidative stress and preventing cellular damage, which may contribute to various chronic diseases, including cardiovascular diseases, cancer, and neurodegenerative disorders.

II. **Anti-inflammatory effects**: Hyperoside has shown anti-inflammatory properties, which can help reduce inflammation in the body. This effect may be beneficial for conditions such as arthritis, inflammatory bowel disease and other inflammatory disorders.

III. **Cardioprotective effects**: Some research suggests that hyperoside may have cardioprotective effects by improving heart health. It may help lower blood pressure, reduce cholesterol levels, prevent blood clots and protect against cardiovascular diseases.

IV. **Neuroprotective effects**: Hyperoside has been studied for its potential neuro protective effects. It may help protect against neurodegenerative diseases like Alzheimer's and Parkinson's by reducing oxidative stress, inflammation and neuronal damage.

V. **Anticancer properties**: There is evidence to suggest that hyperoside may possess anticancer properties by inhibiting the growth of cancer cells, inducing apoptosis (programmed cell death) and preventing angiogenesis (the formation of new blood vessels that feed tumors). Here are some ways hyperoside may exhibit anticancer properties:

i. **Inhibition of cancer cell growth**: Hyperoside has been shown to inhibit the growth and proliferation of various cancer cell lines *in vitro*, including breast cancer, lung cancer, liver cancer, colon cancer and leukemia cells. It exerts its effects by inducing cell cycle arrest, preventing cancer cells from dividing and multiplying uncontrollably.

ii. **Induction of Apoptosis**: Apoptosis, or programmed cell death, is a natural process that eliminates damaged or abnormal cells, including cancer cells. Hyperoside has been found to induce apoptosis in cancer cells through various mechanisms, such as activation of pro-apoptotic proteins and inhibition of anti-apoptotic proteins, ultimately leading to cancer cell death.

iii. **Inhibition of angiogenesis**: Angiogenesis is the process of forming new blood vessels, which is essential for tumor growth and metastasis. Hyperoside has been reported to inhibit angiogenesis by suppressing the production of angiogenic factors, thereby limiting the blood supply to tumors and impeding their growth.

iv. **Suppression of tumor invasion and Metastasis**: Metastasis, the spread of cancer cells to distant organs, is a major contributor to cancer-related mortality. Hyperoside has shown potential in inhibiting the invasion and migration of cancer cells, as well as suppressing the formation of metastatic colonies, which could help prevent the spread of cancer.

v. **Antioxidant and anti-inflammatory effects**: Hyperoside exhibits antioxidant and anti-inflammatory properties, which are important for cancer prevention and treatment. By scavenging free radicals and reducing inflammation, hyperoside may help protect cells from oxidative damage and chronic inflammation, both of which can contribute to cancer development.

vi. **Sensitization to Chemotherapy and Radiotherapy**: Some studies suggest that hyperoside may enhance the sensitivity of cancer cells to chemotherapy and radiotherapy, making them more susceptible to the effects of these treatments. This could potentially improve the efficacy of conventional cancer therapies and reduce the risk of treatment resistance.

However, further studies, including clinical trials, are needed to fully understand its effectiveness and safety for these applications.

VI. **Antimicrobial activity**: Hyperoside has demonstrated antimicrobial activity against various bacteria, fungi, and viruses. It may help inhibit the growth of harmful microorganisms and could be explored for its potential use in fighting infections. Here's how hyperoside may exert its antibacterial effects:

a. **Inhibition of bacterial growth**: Hyperoside has been shown to inhibit the growth and proliferation of several bacterial strains, including both Gram-positive and Gram-negative bacteria. This inhibitory effect on bacterial growth suggests that hyperoside may interfere with essential bacterial processes, such as cell wall synthesis, protein synthesis, or nucleic acid metabolism.

b. **Disruption of bacterial biofilms**: Bacterial biofilms are communities of bacteria enclosed in a protective matrix, making them resistant to antibiotics and immune responses. Hyperoside has demonstrated the ability to disrupt bacterial biofilms, potentially making bacteria more susceptible to antibiotic treatment or immune clearance.

c. **Modulation of bacterial virulence**: Hyperoside may interfere with bacterial virulence factors, which are molecules produced by bacteria to facilitate infection and colonization. By targeting these virulence factors, hyperoside could attenuate bacterial pathogenicity and reduce the severity of bacterial infections.

d. **Enhancement of antibiotic activity**: Hyperoside has been investigated for its synergistic effects with antibiotics. Studies have shown that hyperoside can enhance the antibacterial activity of certain antibiotics, potentially reducing the effective dose of antibiotics needed to treat bacterial infections and minimizing the development of antibiotic resistance.

e. **Mechanism of action**: The exact mechanism by which hyperoside exerts its antibacterial effects is not fully understood. However, it is believed to involve multiple pathways, including disruption of bacterial cell membranes, inhibition of bacterial enzymes, and modulation of bacterial signaling pathways.

f.**Specific bacterial targets**: Hyperoside has been shown to exhibit activity against various bacterial pathogens, including *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhimurium* and others. This broad spectrum of antibacterial activity suggests the potential utility of hyperoside in the treatment of various bacterial infections.

Overall, while hyperoside shows promise as an antibacterial agent, further research, including clinical studies, is needed to fully elucidate its antibacterial mechanisms and evaluate its efficacy and safety for therapeutic use in treating bacterial infections. Additionally, it's essential to consider factors such as bioavailability, pharmacokinetics, and potential side effects when exploring hyperoside as a treatment for bacterial infections.

VII. **Skin Health**: Due to its antioxidant and anti-inflammatory properties, hyperoside may be beneficial for skin health. It could help protect the skin from UV radiation damage, reduce inflammation associated with skin conditions like acne and eczema and promote wound healing.

VIII. **Diabetes Management**: Some studies suggest that hyperoside may help regulate blood sugar levels and improve insulin sensitivity, making it potentially useful in the management of diabetes.

Non therapeutic uses of hyperoside

Apart from its potential therapeutic applications, hyperoside also exhibits various non-therapeutic activities. These include:

1. **Cosmetic applications**:

Hyperoside may be used in cosmetic formulations due to its antioxidant properties, which can help protect the skin from oxidative stress and UV radiation-induced damage. It may also have anti-inflammatory effects that could be beneficial for soothing and calming irritated skin. Here's how hyperoside can be used in cosmetics:

a. **Antioxidant protection**: Hyperoside's antioxidant properties make it beneficial for protecting the skin from oxidative stress caused by free radicals. Exposure to environmental factors such as UV radiation, pollution and toxins can lead to the formation of free radicals, which contribute to premature aging, wrinkles and skin damage. Hyperoside can help neutralize these free radicals, reducing oxidative damage and maintaining skin health.

b. **Anti-inflammatory action**: Inflammation is a common issue in many skin conditions, including acne, eczema and rosacea. Hyperoside's anti-inflammatory properties can help calm and soothe inflamed skin, reducing redness, swelling and discomfort associated with these conditions. Incorporating hyperoside into skincare products can help alleviate inflammation and promote skin healing.

c. **UV protection**: While hyperoside itself does not provide significant UV protection, its antioxidant activity can complement the effects of sunscreen. By scavenging free radicals generated by UV radiation, hyperoside can enhance the skin's defense against sun-induced damage and support the efficacy of sunscreen in preventing sunburn and photoaging.

d. **Skin brightening**: Hyperoside may contribute to skin brightening and complexion improvement by inhibiting melanin production. By reducing the activity of tyrosinase, the enzyme responsible for melanin synthesis, hyperoside can help fade dark spots, hyperpigmentation and uneven skin tone, resulting in a more radiant and even complexion.

e. **Wound healing**: Hyperoside has been shown to promote wound healing by enhancing collagen synthesis and accelerating the regeneration of skin cells. Incorporating hyperoside into skincare formulations can help support the repair of damaged skin, including cuts, scrapes, and minor wounds.

f.**Anti-aging benefits**: The antioxidant and anti-inflammatory properties of hyperoside make it suitable for anti-aging skincare products. By protecting the skin from oxidative damage and inflammation, hyperoside can help minimize the appearance of fine lines, wrinkles and other signs of aging, resulting in smoother, more youthful-looking skin.

g. **Skin conditioning**: Hyperoside can act as a skin conditioning agent, helping to hydrate and soften the skin. Its moisturizing properties make it suitable for use in moisturizers, serums, and lotions, providing hydration and improving skin texture and elasticity.

When incorporating hyperoside into cosmetic formulations, it's essential to ensure proper formulation stability, compatibility with other ingredients, and optimal concentration to achieve desired benefits without causing irritation or adverse effects. Additionally, hyperoside should be used as part of a comprehensive skincare regimen alongside sun protection, gentle cleansing and other skincare practices for optimal results.

2. **Food additive**

Hyperoside is a natural compound found in certain fruits, vegetables and herbs. While it is not typically added directly to foods as a food additive, foods rich in hyperoside may offer health benefits due to its antioxidant properties. However, more research is needed to determine the stability of hyperoside in different food matrices and its potential impact on food quality.

3. **Flavoring agent**: Hyperoside may contribute to the flavor profile of certain plants in which it is naturally found. While it is not commonly used as a standalone flavoring agent, its presence may influence the taste and aroma of foods and beverages.

4. **Research tool**: Hyperoside, like other flavonoids, is often used as a research tool in laboratory studies to investigate various biological processes and mechanisms. Its antioxidant, anti-inflammatory and other pharmacological properties make it valuable for studying cellular

and molecular pathways related to health and disease.

5. **Chemical marker**: Hyperoside can serve as a chemical marker for the identification and quality control of herbal medicines and botanical extracts. Its presence and concentration in plant extracts can be determined using analytical techniques such as high-performance liquid chromatography (HPLC) or mass spectrometry (MS).

6. **Phytochemical screening**: Hyperoside is commonly included in phytochemical screening assays to detect the presence of flavonoids in plant extracts. These screening assays are important for characterizing the chemical composition of medicinal plants and understanding their potential pharmacological activities.

7. **Nutraceuticals and dietary supplements**: Hyperoside is present in certain fruits, vegetables, and medicinal herbs and it may be consumed as part of a balanced diet or as a dietary supplement. It is often included in formulations aimed at promoting overall health and well-being, particularly for its antioxidant and anti-inflammatory effects.

8. **Functional foods and beverages**: Hyperoside-rich foods and beverages may be marketed as functional foods, offering health benefits beyond basic nutrition. These products may include teas, juices, extracts, or snacks fortified with hyperoside to enhance their antioxidant content and promote health.

9. **Herbal medicine**: Hyperoside-containing plants have been used in traditional herbal medicine systems for centuries. Extracts or preparations from these plants may be used to treat various ailments, including inflammatory conditions, gastrointestinal disorders, cardiovascular diseases and more.

10. **Quality control in herbal products**: Hyperoside serves as a chemical marker for quality control and standardization of herbal products and botanical extracts. Its presence and concentration can be used to authenticate herbal materials and ensure consistency and potency in herbal formulations.

11. **Environmental remediation**: Some studies have explored the potential use of hyperoside in environmental remediation efforts. Its antioxidant properties may be useful in scavenging pollutants or neutralizing oxidative stress in contaminated environments.

12. **Educational purposes**: Hyperoside is often used in educational settings to teach students about natural products chemistry, pharmacognosy and phytotherapy. It serves as an example of a biologically active compound derived from plants and highlights the importance of natural

products in medicine and healthcare.

Role of hyperoside in crop plants

In Bhendi plant, hyperoside is highly accumulated during flowering time, as it is a signal substance that affects the length of the flowering period. It has a positive regulatory effect on pollen tube growth and found that hyperoside promotes the depolymerization of microfilaments in a *Nicotiana benthamiana* cell system. Furthermore, it was found that the protein AeADF1 is highly expressed in pollen in response to hyperoside and plays a significant role in pollen germination and pollen tube growth by slice off actin. It revealed that hyperoside promotes the slicing off efficiency of AeADF1 protein on microfilaments to promote pollen germination and pollen tube growth. This research provides new research directions for exploring the mechanism of hyperoside in other plants during flower development.

Such a functionally dynamic compound, hyperoside is found in various plants, particularly in those belonging to the families Hypericaceae, Asteraceae, Rosaceae, Companulaceae, Lamiaceae and Fabaceae, as well as in certain fruits and vegetables such as *Acacia* sp., *Aegopodium* sp., *Ailanthus* sp., *Alnus* sp., *Arbutus* sp., *Arctostaphylos* sp., *Asarum* sp., *Asparagus* sp., *Betula* sp., *Calendula* sp., *Calluna* sp., *Canarium* sp., *Casuarina* sp., *Chimaphila* sp., *Cichorium* sp., *Cornus* sp., *Croton* sp., *Crataegus* sp., *Epilobium* sp., *Eucalyptus* sp., *Euphorbia* sp., *Fagopyrum* sp., *Filipendula* sp., *Geranium* sp., *Glechoma* sp., *Harungana* sp., *Heterotheca* sp., *Hypericum* sp., *Illicium* sp., *Juglans* sp., *Kalmia* sp., *Leonurus* sp., *Lysimachia* sp., *Malus* sp., *Mentzelia* sp., *Menyanthes* sp., *Ononis* sp., *Passiflora* sp., *Persicaria* sp., *Platanus* sp., *Polygonum* sp., *Quercus* sp., *Ricinus* sp., *Rosa* sp., *Salix* sp., *Sambucus* sp., *Selenicereus* sp., *Solidago* sp., *Spigelia* sp., *Syzygium* sp., *Tecoma* sp., *Tilia* sp., *Uncaria* sp., *Vaccinium* sp., *Zanthoxylum* sp.. Here are some plants known to contain hyperoside:

a. **Hawthorn (*Crataegus* spp.)**: Hawthorn species, commonly used in traditional medicine for cardiovascular health, are rich sources of hyperoside.

b. **Bilberry (*Vaccinium myrtillus*)**: Bilberry, a close relative of the blueberry, contains hyperoside along with other flavonoids, contributing to its antioxidant properties.

c. **St. John's Wort (*Hypericum perforatum*)**: St. John's Wort is known for its traditional use in treating depression and contains hyperoside along with other bioactive compounds.

d. **Japanese Raisin Tree (*Hovenia dulcis*)**: The fruit of the Japanese raisin tree contains hyperoside and is used in traditional medicine for its hepatoprotective properties.

e. **Buckwheat (*Fagopyrum esculentum*)**: Buckwheat is a pseudo-cereal known for its nutritional value and contains hyperoside in its seeds.

f.**Rose (*Rosa* spp.)**: Various species of roses contain hyperoside, contributing to their antioxidant and anti-inflammatory properties.

g. **Maidenhair Tree (*Ginkgo biloba*)**: *Ginkgo biloba* leaves contain hyperoside, among other flavonoids, and are used in traditional medicine for cognitive support.

h. **Agrimony (*Agrimonia* spp.)**: Agrimony species contain hyperoside and are used in herbal medicine for their astringent and anti-inflammatory properties.

i.**Lemon Balm (*Melissa officinalis*)**: Lemon balm, a member of the mint family, contains hyperoside along with other bioactive compounds.

j.**Lotus:** particularly the species *Nelumbo nucifera* (also known as Sacred Lotus or Indian Lotus), is known to contain hyperoside among other phytochemicals. Hyperoside is found in various parts of the lotus plant, including the leaves, flowers, seeds, and rhizomes.

These are just a few examples of plants that contain hyperoside. It is worth noting that the concentration of hyperoside can vary among different plant species and even within different parts of the same plant.

Conclusion

Overall, hyperoside is primarily known for its therapeutic potential, it also has various non-therapeutic applications in industries such as cosmetics, food and research. Its diverse properties and applications highlight its importance as a natural compound with multifaceted benefits and uses. Continued research and exploration of its properties may uncover even more uses and opportunities for this natural compound.

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SUCCESS STORY OF KHARIF ONION PRODUCTION IN KODERMA DISTRICT

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Introduction

Farmers of Koderma district are facing the problems of resource poorness, small and scattered land holdings. However, the agriculture is the main source of livelihood of rural population but reduction in productivity day by day is forcing them to migrate in search of job. Majority of farmers are practicing crop cultivation in traditional way, which is not so remunerative. Koderma is situated at an altitude of 397 meters above sea level, between 24.15˚ - 24.49˚ latitude and between 85.26˚ - 85.54˚ longitude. The district forms the northern edge of the Chotanagpur plateau of Jharkhand. Its climate is moderately hot and humid. The average rain fall is 1192 mm and the temperature ranges from 4˚C in winter to 42˚C in summer. The Chotanagpur plateau region Jharkhand offers opportunity for production of kharif onion cultivation in rainy season and harvesting in November- December in commercial scale.

Kharif onion production is not a tradition in Koderma District of Jharkhand . The farmers of Koderma generally cultivate Rabi onion. But due to the factors like shortage of water, irregular electric supply, high temperature, etc. Rabi onion production is also becoming less profitable. Keeping these constraints in view, Digging of kharif onion takes place at the time of Diwali festival when the local onion market is almost finished and onion comes to the market from outside of Jharkhand. At this time the farmer gets higher price or he gets more profit. shri Ramchandra mahto, a progressive farmer of Naitand village Block Jainagar of Koderma

District of Koderma benefits from this. He started the production of kharif onion under the supervision of Dr. Bhoopendra Singh, SMS, Horticulture KVK, Koderma and today about 200 farmers in the district are producing it. KVK, Koderma organized a training programme on production technology of kharif onion & provided literature.




Kharif Onion production at farmer's field

Shri Mahto planned for onion cultivation in kharif onion Cv. Arka Niketan and Agri found dark red (AFDR) 0.5 area. Raised his nursery on raised beds during first week of July under low tunnel polyhouse, transplanted seedlings on flat field in the second week of August. He followed all the recommended package of practices as per advised by KVK scientist. He has harvested onion after 110-120 days and got 12 t/ha marketable onion and sold right at the field @ Rs. 50 per kg which gave him total income of Rs. 4.8 lakh per ha. The B:C ratio was calculated 1:5.33. In this way, he got net profit of Rs. 1.17 lakh from his 0.5 ha.land through Kharif onion production.

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COLONY COLLAPSE DISORDER: KEY FACTORS DRIVING HONEYBEE DECLINE

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Abstract

Colony Collapse Disorder (CCD) represents a perplexing phenomenon contributing to the decline of honeybee populations globally, posing significant ecological and economic ramifications. This abstract delves into the multifaceted nature of CCD and its implications. Colony Collapse Disorder (CCD) manifests as the sudden disappearance of worker bees from hives, leaving behind the queen and immature bees, ultimately leading to colony collapse. While the exact cause remains elusive, key factors such as pesticide exposure, particularly neonicotinoids, and parasitic mite infestations, notably *Varroa destructor*, are widely implicated. Moreover, habitat loss, climate change-induced stressors, and inadequate nutrition exacerbate CCD's impact. Addressing Colony Collapse Disorder (CCD) necessitates a holistic approach encompassing pesticide regulation, sustainable agricultural practices, habitat restoration, and enhanced beekeeping techniques. Understanding the complexities surrounding Colony Collapse Disorder (CCD) is imperative for implementing effective mitigation strategies to safeguard honeybee populations and preserve the critical pollination services they provide for global food security and ecosystem health.

Keywords: Neonicotinoids, Climate change, Agricultural practices, Global food securit Ecosystem health.

Introduction

- Honeybees are one of the most precious insects in the world and are miniature that play an essential role in global agriculture food supply maintenance.
- Honeybees are fascinating eusocial creatures.
- Honey is mildly laxative antiseptic and sedative, generally used in Ayurvedic system of medicine.
- Most of the fruit and vegetable crops are pollinated by honeybees.
- In Maharashtra onion, sunflower, pigeon pea etc. crops depend on honeybees for pollination.
- Beekeeping accounts assets of viable income formation to the rural and tribal farmers and is getting popular in rural India.

Species of honey bees

- The rock bee, *Apis dorsata* (Apidae).
- The Indian hive bee, *Apis cerana indica* (Apidae)
- The little bee, *Apis florea* (Apidae)
- The European or Italian bee, *Apis mellifera* (Apidae)
- Dammer bee or stingless bee, *Melipona irridipennis* (Meliporidae).

What is CCD?

- Colony collapse disorder (CCD) is a phenomenon in which worker bees abruptly disappear from a beehive. Since CCD was first reported on the East coast of the United States in 2006, continued increases in honeybee loss are making CCD an extremely pressing issue. Symptoms of colony collapse disorder include the rapid loss of adult worker bees, few or no dead bees found in the hive, only a small cluster of bees with a live queen present and pollen and honey stores remaining in the hive (Debnam 2009).
- Colony Collapse Disorder and honeybee population decline are very recent developments in the agricultural world and their causes are highly contested.
- One phenomenon that gained fame several years ago and remains a mystery today is CCD.
- CCD gained attention in the year 2006-2007 when beekeepers reported losses in their hive.

- Since 2006, beekeepers have reported higher-than-normal colony losses, which are called colony collapse disorder.
- Bee colonies affected by CCD can appear healthy, but then the adult bees disappear from the colonies.
- If CCD is not resolved, it will severely damage a multi-billion-dollar industry.
- The present review is an attempt to compile the causes of CCD and discuss the management practices to be followed by the beekeepers to avoid the devastating loss to them and the planet Earth.
- CCD has resulted in a loss of 50 to 90 % of colonies in beekeeping operations across the United States.
- In India CCD has caused the decline of *Apis dorsata* in Nilgiri hills of Tamil Nadu. (Kaplan J. K. 2008)

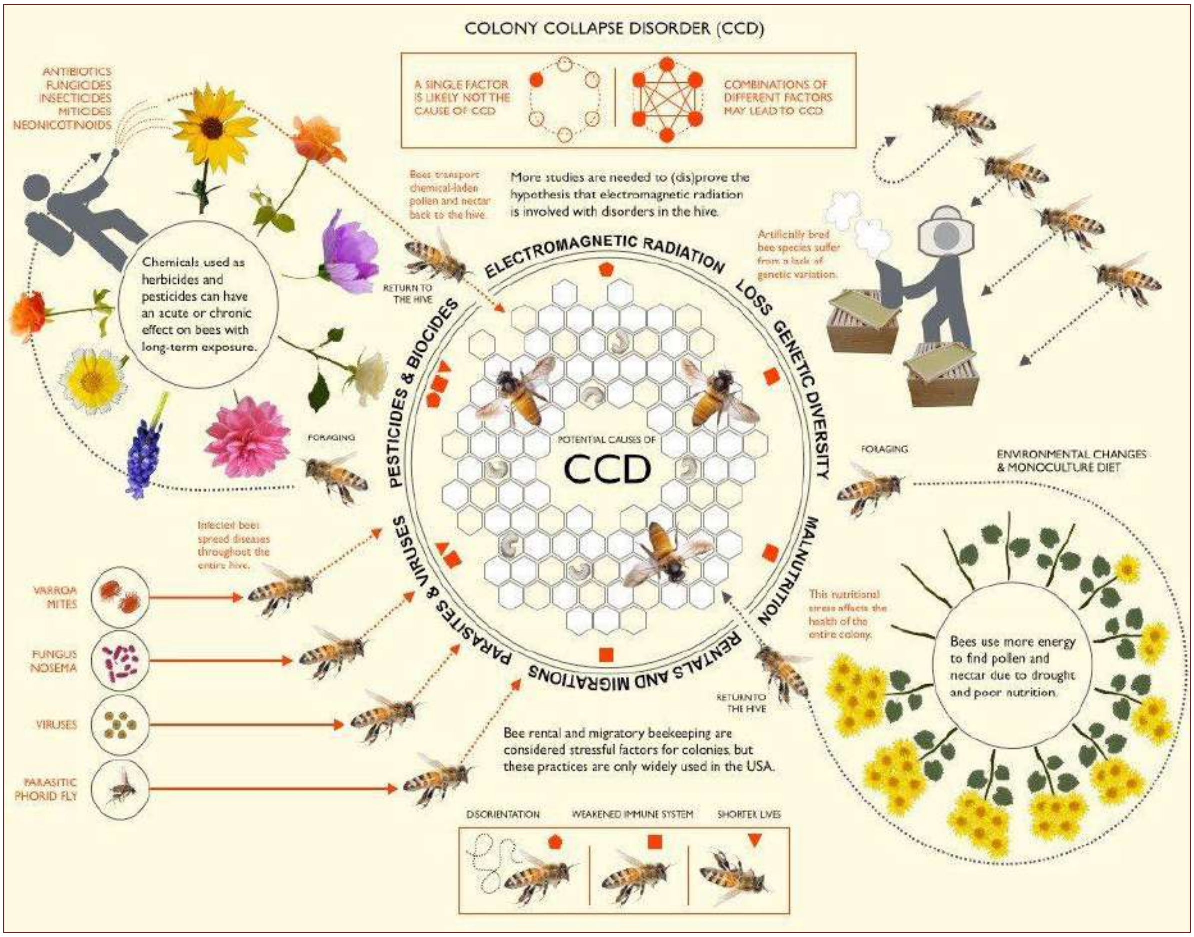
Symptoms

- Presence of capped brood in abandoned colonies.
- Bees normally do not abandon a hive until the capped brood have all hatched.
- Presence of food stores, both honey and bee pollen: that other bees do not rob immediately.
- With significantly delayed attacks by hive pests such as wax moths and small hive beetles.
- Inability to maintain current brood due to low workforce.
- Colony includes mostly young adult bees. (Patel S. and Mall P. 2020)

Causes of Colony collapse disorder (CCD)

- So many reasons like mites, pesticides, fungi, bee keeping practices, immune deficiencies, malnutrition etc. have been reported as causes of CCD but the exact reason is not known.
- Some of the anthropogenic factors that are most likely contributing to collapse include: increased exposure to pesticides, trucking honeybees across long distances for the pollination of commercial 4 crops, poor nutrition, artificial insemination of queens using sperm of limited genetic variability and habitat loss.
- Some causes are:
    - Electromagnetic radiations

- Pesticide poisoning
- Malnutrition
- Pests and Diseases
- Environmental changes
- Heavy metals



Management of Colony collapse disorder (CCD)

- Radiation shielded boxes to protect the bees from EMR. Plant trees and crops nearby so that honeybee need not have to travel a long distance for foraging.
- Apply 3 doses each consisting of 15 ml Polybion SF syrup and 75 mg Oxytetrachloride per colony. After second application the affected bees show significant changes.
- Remove the collapsing colonies and do not combine them with the healthy ones.
- Control the pests of honeybee using integrated pest management. (Chandra *et al*. 2019)
- Keep the hives in a bee friendly garden or orchard so that they get enough food.

- Feed the bees with sugar syrup.
- Destroy the diseased colony including honey, frames and bee hives by burning.
- Use of resistant strains can control CCD, but its evolved only in western countries not in India.

  If possible, avoid applying pesticides during at mid-day when bees are most likely to be out foraging for nectar and pollen. (Chandra *et al*. 2019)

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EXPLORING BIO STIMULANTS: NATURAL SOLUTIONS FOR OPTIMAL CROP GROWTH AND YIELD

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Abstract

Biostimulants offer a promising avenue for sustainable agriculture, providing natural solutions to enhance crop growth and yield. This article delves into the realm of biostimulants, investigating their mechanisms of action, benefits, and potential to revolutionize agricultural practices. From improving nutrient uptake and stress tolerance to promoting plant growth and quality, biostimulants offer multifaceted advantages for farmers and growers. By harnessing the power of nature's own mechanisms, biostimulants pave the way towards greener, more efficient, and sustainable farming practices. This exploration sheds light on the transformative potential of biostimulants in optimizing crop production while minimizing environmental impact.

Keyword: Bio stimulants, crop production, growth and yield.

Introduction

Climate change poses a significant global challenge, impacting various environmental aspects, particularly land degradation, which alters soil quality, vegetation, and productivity. Extreme weather events like droughts, floods, and heatwaves exacerbate soil erosion and nutrient depletion, while shifts in precipitation patterns lead to land abandonment, deforestation, and desertification, threatening food security, water sources, and ecosystems, affecting communities economically and socially. Addressing these issues requires holistic approaches integrating climate-smart agriculture, sustainable land management, and ecosystem-based strategies to enhance resilience and mitigate negative impacts. The increasing demand for biostimulants in agriculture emerges as a crucial solution to enhance resilience and mitigate adverse effects on crop productivity. Biostimulants play a key role in promoting plant growth, nutrient absorption, and stress tolerance amidst shifting climate patterns, thereby contributing to sustainable agricultural practices and optimizing crop yields to ensure food security.

The European Biostimulant Industry Consortium (EBIC) defines "biostimulants" as substances that boost plant nutrition by improving nutrient availability and uptake from the soil, while also enhancing resilience to environmental stresses. Biostimulants, also known as biogenic stimulators, organic biostimulants, and metabolic enhancers, are distinct from fertilizers and pesticides. They aim to enhance nutrient utilization efficiency and promote quality attributes in crops, regardless of their nutrient content, by improving accessibility of nutrients in the soil or rhizosphere. (EU, 2019; Rouphael and Colla, 2020). These materials can be substances and/or microorganisms that enhance plant growth, increase tolerance to unfavourable environmental conditions, and promote efficient use of plant resources. (Yakhin et al., 2017). Biostimulants are obtained from, for example, microorganisms, plant- or animal-based by-products recycled from the food industry, or seaweed extracts.

Key classifications of plant biostimulants

Humic and fulvic acids

Humic substances (HS) are naturally occurring components of soil organic matter, formed through the decomposition of plant, animal, and microbial residues, as well as the metabolic processes of soil microbes utilizing these substrates. The complexes of humic substances in soil arise from the interaction among organic matter, microbes, and plant roots. Therefore, any endeavor to harness humic substances for enhancing plant growth and crop yield must focus on optimizing these interactions to attain desired outcomes.

Humic substances play a crucial role in enhancing soil fertility by influencing its physical, physicochemical, chemical, and biological properties. They primarily act as biostimulants by improving root nutrition through multiple mechanisms. This includes increasing the uptake of macro- and micronutrients, enabled by the enhanced cation exchange capacity of soil containing polyanionic humic substances. Additionally, humic substances disrupt calcium phosphate precipitation, leading to heightened phosphorus availability. Another key aspect is their ability to stimulate plasma membrane H+-ATPases, which facilitate the import of essential nutrients like nitrate across cell membranes. (Jindo *et al.*, 2012).

Protein hydrolysates and other N-containing compounds

Amino acid and peptide mixtures are derived from agroindustrial by-products through chemical and enzymatic hydrolysis of proteins found in both plant sources such as crop residues and animal wastes like collagen and epithelial tissues. Chemical synthesis methods are also employed to produce individual or mixed compounds. Additional nitrogenous molecules include betaines, polyamines, and "non-protein amino acids," which are abundant in higher plants but not extensively characterized regarding their physiological and ecological roles**.** (Vranova *et al.*, 2011). Glycine betaine, a derivative of amino acid, is notable for its well-established anti-stress properties. (Chen and Murata, 2011). Some amino acids, such as proline, exhibit chelating effects, which can shield plants from heavy metal toxicity while also aiding in the mobility and uptake of micronutrients. Certain nitrogenous compounds, including glycine betaine and proline, possess antioxidant properties by scavenging free radicals. This antioxidant activity helps alleviate environmental stress.

Seaweed extracts and botanicals

Although the practice of using fresh seaweeds as organic matter and fertilizer dates back to ancient agriculture, their biostimulant effects have only recently been recognized. This has led to the commercialization of seaweed extracts and purified compounds, including laminarin, alginates, carrageenans, and their derivatives, which contribute to plant growth promotion. Other constituents aiding in this process include micro- and macronutrients, sterols, nitrogen-containing compounds like betaines, and hormones. Many of these compounds are unique to their algal source, driving increased interest from both the scientific community and industry. While most algal species belong to the brown algae phylum, carrageenans are derived from red seaweeds, representing a distinct phylogenetic line. Khan *et al.* (2009) have identified over 20 seaweed products used as biostimulants in plant growth.

Chitosan and other biopolymers

Chitosan, derived from the deacetylation of chitin, is utilized in various sectors such as food, cosmetics, medicine, and agriculture, with poly- and oligomers of controlled sizes being employed. Its physiological effects in plants stem from its ability to bind cellular components, including DNA, plasma membrane, and cell wall constituents, and specific receptors involved in defense gene activation, resembling plant defense elicitors. Distinct from chitin, chitosan utilizes separate receptors and signaling pathways. Its binding to cell receptors triggers hydrogen peroxide accumulation and calcium leakage, crucial in stress response signaling and development regulation. Proteomic and transcriptomic analyses of chitosan-treated plant tissues confirm significant physiological changes. Agricultural applications of chitosan primarily focus on fungal pathogen protection, alongside broader roles in abiotic stress tolerance and quality trait enhancement through modulation of primary and secondary metabolisms. Chitosan-induced stomatal closure, mediated by an ABA-dependent mechanism, contributes to its biostimulant role in environmental stress protection.

Inorganic compounds

Chemical elements that enhance plant growth and may be vital for certain plant taxa but not universally required are termed beneficial elements. These include aluminum (Al), cobalt (Co), sodium (Na), selenium (Se), and silicon (Si), which exist in soils and plants in various inorganic salts and insoluble forms like amorphous silica ($SiO_2.nH_2O$), particularly in graminaceous species. The beneficial roles of these elements can be inherent, such as silica deposits reinforcing cell walls, or activated under specific environmental conditions, such as selenium's role during pathogen attacks and sodium's involvement in osmotic stress responses.

Inorganic salts of beneficial and essential elements, such as chlorides, phosphates, phosphites, silicates, and carbonates, have been utilized as fungicides. Although their exact modes of action remain unclear, these compounds influence osmotic balance, pH levels, redox homeostasis, hormone signaling, and stress-responsive enzymes like peroxidases. Apart from their fungicidal properties and role as nutrient sources in fertilizers, their potential as biostimulants for enhancing plant growth, improving nutritional efficiency, and bolstering tolerance to abiotic stress warrants further investigation.

Beneficial bacteria

Beneficial bacteria engage with plants across various interactions, ranging from mutualism to parasitism. They inhabit diverse niches, spanning from soil to intracellular spaces, including the rhizosphere and rhizoplane. These associations can be temporary or enduring, with some bacteria transmitted vertically through seeds. Their functions encompass contributions to biogeochemical cycles, nutrient supply, enhanced nutrient utilization efficiency, disease resistance induction, abiotic stress tolerance enhancement, and regulation of plant growth via growth regulators.

The main effects of biostimulants on vegetable crops are summarized in Table 1.

Sr. No.	Name of Crop	Biostimulant Compound	Effects	References
1.	Onion	Humic acids, amino acids, organic substances carbon and boron or algae extracts.	Increased plant growth and yield and bulbs shelf life	Shehata, *et al.*, (2017).
2.	Tomato	Incorporation of humic acids and/or crushed maize grain	Stimulant shoot, root growth, increased RWC and MSI transplants, improved macronutrients uptake	Rady and Rehman (2016).

Table 1. Some biostimulants effects on various vegetable crops.

Extraction method of Biostimulant

Various extraction methods are employed to obtain biostimulants, each offering unique advantages and characteristics. These techniques range from traditional to modern, encompassing processes such as solvent extraction, enzymatic hydrolysis, and mechanical pressing.

Extraction technique	Extraction technique
Infusion	A fresh infusion is created by steeping the raw material in cold or boiling water for a brief duration.
Digestion	This technique, a variant of maceration, involves applying heat during extraction. It's utilized when raising the temperature enhances solvent effectiveness without compromising substance stability.
Hot Continuous Extraction (Soxhlet)	This method is employed when the desired compound exhibits low solubility in a solvent. The process involves placing the material in a porous bag, while the extracting solvent is housed in a separate vessel. Upon heating, the condensed vapors of the solvent drip into the bag containing the raw material, facilitating compound extraction through contact.
Aqueous Alcoholic Extraction by Fermentation	The crude material undergoes soaking for a predetermined duration, initiating fermentation and the in-situ production of alcohol. This process aids in the extraction of the active constituents present in the plant material.

Counter-current extraction (CCE)	The wet raw material is introduced into a cylindrical extractor, where it comes into contact with the extraction solvent. This method is characterized by high efficiency, requiring minimal time and posing no risk from high temperatures.

The benefits of biostimulants in agriculture are manifold and include

1. Biostimulants promote root development, vegetative growth, and overall plant vigor, leading to increased biomass production.

2.They enhance the uptake and utilization of essential nutrients, ensuring optimal nutrient efficiency and reducing nutrient wastage.

3. Biostimulants help plants cope with various environmental stresses such as drought, salinity, temperature extremes, and disease pressure, improving crop resilience and survival rates.

4. They enhance the quality and nutritional value of crops by increasing nutrient content, improving taste, texture, and appearance.

5. Biostimulants offer a natural and environmentally friendly approach to farming, reducing reliance on synthetic fertilizers and pesticides while promoting soil health and biodiversity.

6. By optimizing plant growth and stress tolerance, biostimulants ultimately lead to higher yields and improved crop productivity.

The application methods for biostimulants vary depending on the specific product and the target crop

Foliar spray

Foliar spray is a commonly employed method for applying biostimulants, involving the direct application of the product onto the leaves of plants using a sprayer. This method allows for efficient absorption of the biostimulant through the plant's stomata, leading to rapid uptake and utilization by the plant. Foliar application is particularly beneficial for providing quick responses and addressing specific nutrient deficiencies or stress conditions in crops.

Soil drench

In soil drench application, biostimulants are directly applied to the soil around the plant's root zone. This method ensures gradual uptake of the biostimulant by the roots, allowing for sustained benefits over time. By delivering nutrients and enhancing root development directly to the plant's root system, soil drenching promotes overall plant health and vigor, contributing to improved growth, yield, and stress tolerance.

Seed treatment

Seed treatment with biostimulants involves coating seeds with biostimulant solutions prior to planting, accomplished through techniques like soaking, coating, or pelleting. These methods enhance seed germination, root development, and early plant growth, crucial for optimizing crop establishment and overall performance.

Root dip

Root dip application involves soaking plant roots in a biostimulant solution before transplanting into soil, facilitating direct uptake of biostimulants. This enhances root development, nutrient absorption, and overall plant growth, improving establishment, vigor, and stress tolerance (Molla *et al.*, 2019). By delivering a concentrated dose of biostimulants directly to roots, this method ensures swift and effective delivery of beneficial compounds, fostering healthier and more resilient plants across agricultural contexts.

Challenges and Future Directions

Standardized protocols are crucial for evaluating biostimulant efficacy across different crops, environments, and application methods, but their absence hinders research progress. While biostimulants have positive effects on plant growth, their mechanisms are poorly understood, necessitating further research. Economic viability is a challenge for widespread biostimulant adoption, requiring evaluation against conventional practices. Regulatory differences between countries affect biostimulant registration and marketing, emphasizing the need for harmonization to build consumer trust and facilitate market entry.

Conclusion

Biostimulants offer a sustainable and environmentally friendly approach to agriculture, harnessing the power of natural compounds to enhance plant growth, resilience, and productivity. From improving nutrient uptake and utilization efficiency to bolstering stress tolerance and overall plant vigor, biostimulants provide a holistic solution for modern farming challenges. As we continue to delve into the potential of biostimulants, it becomes increasingly evident that they hold the key to unlocking sustainable and resilient agricultural practices. By integrating biostimulants into farming systems, we can pave the way towards a greener, more efficient, and more productive agricultural future.

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AGRICULTURAL RELEVANCE OF NANOBIOFERTILIZERS

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Introduction

In the quest for sustainable agriculture, scientists are turning to an unlikely hero: nanotechnology. Nanobiofertilizers, the cutting-edge solution poised to revolutionize farming practices and address global food security challenges. Traditional fertilizers have long been the backbone of modern agriculture, but they come with drawbacks such as nutrient runoff, soil degradation, and environmental pollution. Nanobiofertilizers, a game-changing innovation that leverages nanotechnology to enhance nutrient delivery, improve soil health, and boost crop yields while minimizing ecological harm (Paramo et al. 2020).

Nanobiofertilizers are nano-sized particles loaded with essential nutrients, beneficial microbes, and bioactive compounds. These nanoparticles act as carriers, delivering nutrients directly to plant roots with unparalleled efficiency. One of the key advantages of nanobiofertilizers lies in their ability to overcome the limitations of traditional fertilizers. By precisely controlling the release of nutrients, nanobiofertilizers ensure optimal uptake by plants, reducing wastage and environmental impact. Additionally, they promote soil microbial activity, fostering a healthy ecosystem that enhances nutrient cycling and improves soil fertility over time (Liu and Lal, 2015).

But the benefits of nanobiofertilizers extend beyond nutrient delivery. They also exhibit remarkable properties that enable them to mitigate environmental stresses such as drought, salinity, and pests. Through nanotechnology, scientists can engineer nanoparticles with specific functionalities, such as drought-resistant polymers or insect-repelling compounds, providing crops with an added layer of protection against adverse conditions. Furthermore, nanobiofertilizers offer a sustainable alternative to chemical fertilizers, reducing reliance on synthetic inputs and minimizing the carbon footprint of agriculture. By promoting soil health and enhancing nutrient efficiency, they contribute to the long-term sustainability of farming practices, ensuring a healthier planet for future generations (Rameshaiah et al. 2015).

While nanobiofertilizers hold immense promise, their widespread adoption hinges on continued research, regulatory oversight, and public acceptance. Scientists are actively exploring new formulations, delivery mechanisms, and application techniques to optimize their efficacy and minimize potential risks. In the face of mounting environmental challenges and a growing global population, nanobiofertilizers represent a beacon of hope for sustainable agriculture. By harnessing the power of nanotechnology, we c
an cultivate healthier crops, preserve precious resources, and build a more resilient food system for the years to come.

Applications of nanobiofertilizers for sustainable agriculture:

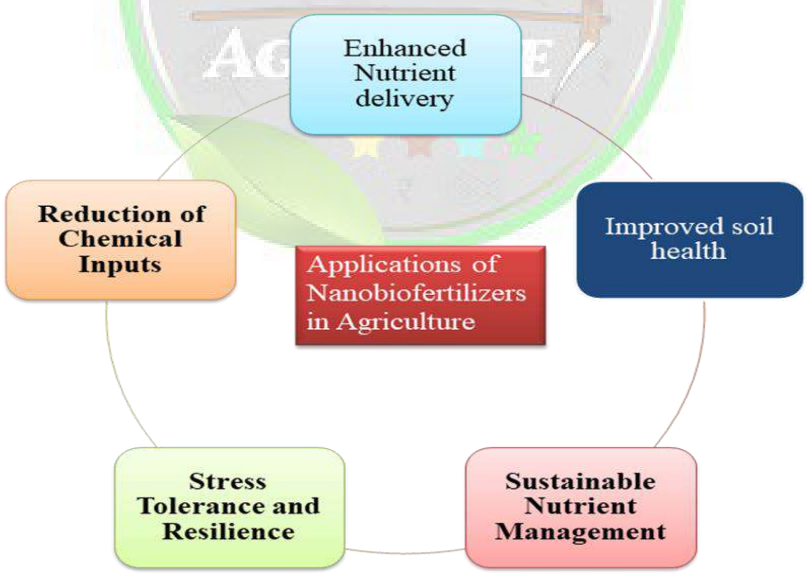

Figure 1: Multifarious applications of Nanobiofertilizers

Enhanced Nutrient Delivery

Nanobiofertilizers are designed to deliver nutrients directly to plant roots with high efficiency. By encapsulating essential nutrients such as nitrogen, phosphorus, and potassium within nano-sized particles, nanobiofertilizers ensure targeted delivery, minimizing nutrient wastage and maximizing plant uptake. This targeted approach promotes healthier plant growth while reducing the need for excessive fertilizer application, thereby mitigating nutrient runoff and soil pollution.

Improved Soil Health: Nanobiofertilizers promote soil health by enhancing microbial activity and nutrient cycling. Beneficial microorganisms, such as nitrogen-fixing bacteria and mycorrhizal fungi, can be incorporated into nanobiofertilizers to stimulate soil microbial communities. These microbes play a crucial role in breaking down organic matter, releasing nutrients, and improving soil structure, leading to increased fertility and resilience against environmental stresses.

Sustainable Nutrient Management:

Traditional fertilizers often leach into groundwater or runoff into water bodies, causing pollution and ecosystem degradation. Nanobiofertilizers offer a sustainable alternative by reducing nutrient loss through controlled release mechanisms. Nanoparticles can be engineered to release nutrients gradually, matching the plant's demand over time. This not only minimizes environmental impact but also ensures a steady nutrient supply for optimal plant growth.

Stress Tolerance and Resilience:

Nanobiofertilizers can enhance crop resilience to environmental stresses such as drought, salinity, and pests. Nanoparticles can be functionalized with stress-responsive compounds or bioactive molecules that help plants withstand adverse conditions. For example, nanoparticles coated with drought-tolerant polymers can improve water retention in soil, while those infused with insect-repelling compounds can deter pest infestations, reducing the need for chemical pesticides.

Reduction of Chemical Inputs:

By promoting nutrient efficiency and pest resistance, nanobiofertilizers reduce the reliance on chemical fertilizers and pesticides. This not only minimizes the environmental footprint of agriculture but also contributes to cost savings for farmers. Furthermore, the reduced use of synthetic inputs helps preserve soil health, biodiversity, and ecosystem integrity, fostering a more sustainable agricultural system in the long run.

Table 1: Advantages and disadvantages of nanobiofertilizers

Advantages	Disadvantages
Three times increase in nutrient use efficiency(NUE).	There are concerns about the potential environmental and health risks associated with nanoparticles, especially when they are not adequately contained or controlled.
80-100 times less requirement to chemical fertilizers	Developing and producing nanobiofertilizers can be more expensive than traditional fertilizers. The higher cost may limit their adoption, especially among small-scale farmers.
10 times more stress tolerant by the crops.	The long-term effects of nanobiofertilizers on soil and ecosystem health are not yet fully understood.
Complete bio-source, so eco-friendly	Farmers may need specific knowledge and training to use nanobiofertilizers effectively, which could be a barrier to adoption, particularly in regions with limited resources.
30% more nutrient mobilization by the plants	Nanobiofertilizers are not widely available in many agricultural markets. Widespread adoption may be limited by their accessibility.

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A SUCCESS STORY ON INTEGRATED PEST MANAGEMENT (IPM) IN BRINJAL CROP BY THE FARMERS OF DABBARI VILLAGE, DHALAI DISTRICT, TRIPURA

Article ID: AG-VO4-I04-113

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Introduction

The majority of the farmers from Dabbari village and adjoining villages from Dhalai District, Tripura grows a different kind of vegetables during *Rabi* season following paddy during *Kharif* season. Among the vegetables Brinjal (*Solanum melongena* L.) is one of the most important and popular vegetable crops mostly grown by farmers. Although several varieties of brinjal are cultivated by the farmers the expected yield of the crop is not achieved so far because of the crop damage caused by insect pests like fruit & shoot borers and some other insects attack the brinjal crops which reduces the crop yield.

Name of the farmer & Address:

Mahitosh Das

S/O- Promod lal Das

Vill- Dab bari 32 cut, P.O- Machuria,

Dist: Dhalai, Tripura, PIN- 799278

Phone no.: 8014977075

Initial status / Practice of farmer before KVK

Intervention

- This the major pest in brinjal cultivation in the State
- High incidence of the pest with a high percentage of severity
- Unawareness of fruit and shoot borer integrated management practices
- Reduction in yield due to high infestation
- Lack of knowledge of sucking pest mechanism
- Less availability of suitable biopesticides

KVK Intervention:

To overcome this problem in brinjal crop cultivation Krishi Vigyan Kendra Dhalai, Salema, took the initiative to introduce a pheromone trap as FLDs on Integrated Pest Management (IPM) in brinjal crop to control the insect pests like fruit and shoot borers during the year 2021-22. Training and critical input like pheromone trap was provided to the selected beneficiaries and time-to-time field monitoring was done to the farmer's field by the institution. As continuous monitoring aids in the timely detection and early warming of the pest, identifying the peak of occurrence and timing of insecticidal application also helps in avoiding unnecessary chemical sprays and timely application of pesticides when absolutely essential. Thus pheromone has a major role in Brinjal IPM, which is effectively used for the early detection of the pest and to monitor its seasonal activity in order to schedule appropriate plant protection measures.

Output and outcome

A total of 120 nos. of traps was provided to the selected beneficiaries for a demonstration unit purpose. Farmers' feedback was recorded. The majority of the farmers were happy with this technique as after using this pheromone trap in the Brinjal crop, they observed the less use of chemical sprays and insect pest attacks of the crop, which saves their crop and money for excess buying of insecticides. It allows the farmer to harvest the good and healthy Brinjal fruit for marketable surplus and increases the average net return from about Rs.99000/- to Rs. 1,57,000/- per hectare

Result & Discussion:

Package of practice	% shoot damage	% fruit damage (Weight basis)	Yield (MT/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
IPM	5.25	16.62	19.83	78000	237960	157960	3.05
Farmers practice	7.20	19.73	15.41	85000	184920	99920	2.17
Control (untreated)	14.68	42.57	8.95	70000	107400	37400	1.53

By adopting the IPM practice yield of 19.83 Mt could be obtained in comparison to farmers' practice where the yield obtained was 15.41 Mt moreover the cost of production was higher in the case of farmers' practice due to the high use of pesticides. IPM practice adopted under the demonstration programme not only reduces the cost of production but also decreases the infestation level and increases the fruit yield. Farmers who undertook the demonstration are very much happy to see the results.

Visit of Dr Mukesh Sehgal, Principal Scientist, ICAR NCIPM, New Delhi to the field of Shri Mahitosh Das

Impact

The IPM strategy was implemented in farmers' fields as a pilot project basis in a demonstration unit in selected areas of Dhalai District, Tripura, and its use was extended in the adjoining villages too. It was observed that earlier farmers applied 3 – 4 times chemical spray in a week. Now, after using this pheromone trap chemical spray reduces from 3-4 times to once in a week. Labour requirements decreased for those farmers who adopted this IPM technology. Farmers' profit margins and production levels increased significantly. Less use of chemical sprays reduces the environmental risk associated with pest management and provides economic benefits due to sustained development, increased productivity, and reduced pest damage.

Shri Mahitosh Das received an award and appreciation letter from ICAR NBAIR, Bangaluru for adopting the IPM practices and also influencing more than 200 farmers in Dhalai District

The majority of the farmers were happy as this technique is environment friendly, improves the crop quality, reduces the chemical sprays, and preserves the soil fertility level. After seeing this result, now they want to expand more areas under Brinjal cultivation by using the pheromone trap. More than 2500 Nos of brinjal cultivating farmers are adopting and practicing this technology and the State Govt has also adopted this technology in their MIDH, State Plan and ATAM Schemes in the district.

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ARTIFICIAL INTELLIGENCE: APPLICATIONS IN CROP IMPROVEMENT

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Abstract

Recently, farming has seen a significant application of artificial intelligence (AI). The agriculture industry is using AI technology to grow healthier crops, control pests, monitor soil and growth conditions, analyse data for farmers, and improve other food supply chain management tasks. AI assists farmers in selecting the best seed for a given set of meteorological conditions. AI-powered solutions will improve crop quality, enable farmers to produce more with fewer resources, and accelerate the time it takes for products to reach the market. By recommending fertilizers to apply to improve soil quality, AI benefits farmers. AI can assist farmers in determining when to plant their seeds. A health monitoring system, driven by artificial intelligence, gives farmers data on the condition of their crops and the nutrients that need to be given to enhance yield quality and quantity. This study identifies and analyses relevant articles on AI for crop improvement.

Keywords: Artificial intelligence; applications; crop improvement; AI techniques

Introduction

Globally, the topic of agricultural automation is becoming more and more popular. AI has seen a lot of direct application in agriculture in recent years. In addition to helping farmers do more with less, AI-powered solutions will guarantee faster time to market for crops while also enhancing quality. The creation and application of remote sensing technologies for the identification and control of plants, weeds, pests, and diseases is made possible by developments in computer vision, mechatronics, artificial intelligence, and machine learning. AI technologies have the potential to help farmers not only reduce wastage but also enhance the quality and speed up crop delivery to markets. The following are a few applications that aim to enhance crops with artificial intelligence:

Analysing farm data using AI

Farmers can now extract and analyse data from their field in real time, including weather, temperature, water usage, and soil condition, thanks to artificial intelligence. Precision farming, which uses artificial intelligence technology to select crops more accurately and efficiently, is already helping farmers increase yields through improved resource management, hybrid seed selection, and crop quality. In order to determine which pesticides and weedicides should be applied in the designated buffer zone, AI sensors are able to identify and target weeds. This aids in maximizing the quantity of herbicides and insecticides that farmers should apply. Additionally, AI is helping farmers create seasonal forecast models to improve farming accuracy and improve productivity. Farmers are employing AI-enabled cameras mounted on drones to capture images in the field and analyse them in real time to spot possible issues and make adjustments, in addition to collecting topographic data. Compared to humans, drones can cover a far larger region and monitor produce more effectively.

Yield management using AI

Today's smart agriculture ecosystem is made possible by artificial intelligence (AI), cloud computing, satellite images, and advanced analytics. By combining these technologies, farmers may increase average yields and have more price control. By integrating weather forecasts with AI to analyse meteorological conditions, farmers may plan what kind of crop can be cultivated and when to plant seeds. AI can help farmers choose which crops will yield the highest profits by simplifying the process of crop selection. Through the use of forecasting and predictive analytics, farmers may reduce the likelihood of crop failure and remove errors in business processes. The data analysis facilitates the development of a probability model to identify the genes that are most likely to confer a favourable trait to a plant. ANN technique predicts crop yield.

Tackling the labour challenges

Today, the mass migration of labour to the city is impeding farm operations. AI-enabled robots are improving labour productivity in a variety of ways. These robots decrease operating expenses and labour dependency by harvesting more quickly and correctly locating and removing weeds. Farmers are already looking to chatbots for assistance in the interim. Chatbots assist farmers by responding to their inquiries and offering counsel and direction on particular farming-related matters

Identify wasteful resource consumption patterns

AI systems have the potential to identify patterns of excessive resource consumption and provide optimization solutions by analysing and interpreting data on resource allocation and consumption. As AI improves yields without requiring farms to use more resources and lowers costs associated with various stages of agricultural operations, a gain in profitability is a natural and beneficial side consequence. PROLOG removes less used farm tools from the farm.

Detect soil defects

By analysing data from sensors buried in the ground, supplied by drones conducting soil research, or acquired from smartphone cameras, artificial intelligence (AI) solutions may be able to identify nutrient deficiencies and soil flaws. Farmers can use this information to determine how much organic matter to add to the soil in order to improve its adaptability and workability. To provide more precise forecasts, data from various sources such as temperature, soil, humidity, weather, crop performance, and others are analysed using drone photography to measure and forecast the effects of the environment on crop yield.

Identifying locations for sowing specific crops

AI may assist agricultural workers in selecting the best locations for crops to be planted based on the topography of the region, the composition of the soil, or any other criterion by analyzing images captured by drones. The current crops and seed quality will be determined using a supervised machine learning system. Before seeds are sown, AI might scan seed photos and compare them to images of healthy seeds.

Detect the smallest insects

Artificial intelligence algorithms find small insects. Farmers may take the appropriate safeguards because notifications are provided straight to their smartphones when an incursion is detected. To increase agricultural health and productivity, AI focuses on examining faulty crops and identifying pests. Technology is assisting in the improvement of crop management techniques. By employing less resources, farmers can boost crop productivity without sacrificing quality. Big data, AI, and ML can be used to build models that identify pests and illnesses and provide real-time analysis to improve crop health. ANN and FUZZY Logic application of AI reduces insects that attack crops.

Proper guidance

By offering appropriate recommendations in a number of areas, such as crop rotation, harvesting schedule, water management, crop type in the weather, ideal planting, insect control, and nutrition management, artificial intelligence (AI) technologies educate farmers about precise and regulated agricultural practices. Decision-making is enhanced by AI. AI is widelyused by farmers to handle crucial problems such as price forecasts, irrigation scheduling, harvesting, and market demand analysis. Saving money is another benefit of farming. CALEX technique can formulate scheduling guidelines for crop management activities.

Drive predictive analytics

Predictive analytics is the main application of AI in agricultural sowing, helping to determine when and how to seed. With the use of climate data, past experiences, input and output market conditions, individual information, and other factors, it helps estimate the best times to plant, apply fertilizer, harvest, bale, till, and engage in other agricultural activities. Additionally, crops may be sown at optimal depths and uniform intervals with the aid of AI-assisted technology. Using AI, IoT, linked services, and autonomous systems, farmers can make decisions at the level of the individual plant or square meter as opposed to the level of entire fields.

AI startups in agriculture

Globally, efforts are focused on automating agricultural processes and utilizing artificial intelligence (AI) and related technologies to optimize agriculture through data inputs. Numerous start-ups have been established as a result of this.

1. **Prospera:** This startup has developed a cloud-based system that gathers all the data that farmers may access, including photographs from the air, sensors on land and water, and more. It then links to professional guidance that evaluates the data and makes recommendations for the intended outcomes. Prospera is a versatile tool that can be used in greenhouses and outdoors. It utilizes a range of sensors and computer vision technologies to assess the link between different data labels and their predictions.

2. **Blue river technology**: integrates robots, AI, and computer vision to cut expenses and minimize the use of pesticides. Each plant is identified individually by computer vision, while machine learning establishes how each plant's features should be studied. This enables the robot

to operate farm machines intelligently and to take appropriate action.

Farmbot: established in 2011 and has raised the bar for precision research by utilizing home farmers to engage with the community through precision farming methods. Using robots that are controlled by an open-source software system, farmers are able to carry out a variety of tasks, such as watering plants, weed detection, soil testing, and seed planting

3. **Harvest CROO Robotics**: is a robotic strawberry harvesting system that uses artificial intelligence and machine vision to identify and recognize ripe berries for strawberry picking. A severe labor shortage affects strawberry growers, driving up crop costs and raising the possibility of an incomplete harvest. Manufacturers' labor costs will be decreased, harvesting efficiency will rise, and overall competitiveness will be enhanced by the development of mechanical harvesting techniques and the application of other artificial intelligence.

4. **Gramophone (Agstack technologies):** they use image recognition skills to help farmers get the right information, methods and materials at the right time to get the best harvest possible. The company uses AI and machine learning to predict food prices to maximize productivity, and recommend products to farmers.

Jivabhumi: Jivabhumi is an Agri- tech platform for connecting farmers directly with Institutional buyers and consumers. Jivabhumi partners with farmers, farmers group, aggregates farm produce and makes it traceable leveraging BLOCKCHAIN enabled platform called FOOTPRINT. Jivabhumi enables consumers (B2C) and institutional buyers (B2B) to buy chemical, pesticide free and traceable farm produce directly

Challenges in adoption of AI

While AI has huge potential for agricultural applications but still lack the use of high- tech machine learning solutions. Sometimes what AI would take a good decision in planning stage might not prove to be the best one because of changes in external factors.AI systems require a lot of data to train machines and make accurate predictions. It is difficult to find temporal data for large agricultural areas. Because data infrastructure requires maturity, it takes time to develop a powerful machine learning model. This is one of the reasons why AI is used in agricultural products like seeds, fertilizers and pesticides, rather than field solutions.

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A SUCCESS STORY-ADOPTION OF BACKYARD POULTRY FOR LIVELIHOOD SECURITY IN BAGESHWAR DISTRICT OF UTTARAKHAND

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Abstract

Backyard poultry farming is a source of animal protein and income for small, marginal, and landless farmers. It is also a source of better livelihood for farmers. In India, about 65 percent of the human population lives in villages where the staple food is either rice or wheat and the protein intake is considerably low. It is essential to provide nutritious food with supplementation of animal protein to these rural and tribal people to protect them from protein malnutrition and ensure their proper growth and sound health. Though the intensive production system is well established, backyard poultry farming (BYPF) with improved chicken varieties or native breeds is gaining popularity in the recent past as a potential tool to alleviate protein hunger and generate subsidiary income among the rural and tribal people across the country.

Introduction

In India, about 65 percent of the human population lives in villages where the staple food is either rice or wheat and the protein intake is considerably low. It is essential to provide nutritious food with supplementation of animal protein to these rural and tribal people to protect them from protein malnutrition and ensure their proper growth and sound health. Though the intensive production system is well established, backyard poultry farming (BYPF) with improved chicken varieties or native breeds is gaining popularity in the recent past as a potential tool to alleviate protein hunger and generate subsidiary income among the rural and tribal people across the country.

Backyard Poultry production is an effective income generating enterprise especially for small and marginal farmers. The climatic condition of district Bageshwar is very conducive for backyard poultry farming. It provides additional income and nutritional security for hill farmers. It can be easily started as a single venture or along with agriculture or animal husbandry. Since, animal protein in the form of chicken and eggs required for growth and repair of the human body. Hence, this venture also corrects the protein deficient problems. By considering all these factors, KVK, Kafligair- Bageshwar has started Backyard Poultry Farming (BPF) training and demonstrations. Its main objective is to incorporate animal protein in the food of rural poor farmers for reducing protein deficient problems as well as generation of revenue for their better livelihood. This has led to spread this technology among the famers.

Interventions

During last seven years awareness through training and demonstrations on Backyard Poultry Farming (BPF) were conducted at KVK farm as well as at farmer's doorstep by using Chabro-dual purpose chicks. In BPF the main problem faced by the farmers is high mortality rate in chicks during brooding period (0-21 days). For solving this problem, KVK Bageshwar gave hands on training to rural youth for temperature and health management of day old chicks during brooding period. The few rural youth were selected and trained for establishment of poultry mother unit. KVK Bageshwar supported with critical input like chicks, starter feed and vaccines during first 20 days. Later on, 20 days grown up chicks were distributed to selected trained farmers. It has been seen that after COVID -19 period more educated rural youth are showing their interest in poultry farming. Initially they started with small unit and later on converted into poultry entrepreneurship.

Output:

These efforts led to adoption of backyard poultry production. The overall 70 percent adoption rate was recorded during last seven years. The adoption and income details of the BPF enterprise during last seven years are given in table -1. The average cost of production, gross income, net income and BC ratio of BPF demonstrations are **Rs** 68756.71, **Rs 137012.30, 68255.50 and 1.99, respectively.**

Outcomes

Now the farmers have started poultry production by self financial help or with the assistance of district animal husbandry department or under MNREGA scheme.

Rearing of chicks during brooding period by master trainer

Backyard poultry demo at Ranjeet Singh farmer of Baidibagar village

Small demo of Backyard poultry at KVK Campus , Kafligair, Bageshwar

Encouraging Rural Youth (Shri Chandan Singh) for Backyard poultry farming.

Encouraging Farmers (Shri Heera Singh) for organized poultry farming

Table- 1 Activates carried out and economics on backyard poultry farming (BPF)

Year	No. of Training	No. of chicks per unit	No of beneficiaries	Mortality rate (%)	Total cost (Rs.)	Gross income (Rs.)	Net income (Rs.)	BC ratio	No. of farmer's adopted
2014-15	4	20	30	05	56845	111150	54305	1.95	18
2015-16	4	20	30	10	57950	113400	55450	1.96	20
2016-17	4	20	25	5	51000	104500	53500	2.05	20
2017-18	4	20	30	3	61200	128040	66840	2.09	20
2018-19	5	20	25	2	66802	128625	61823	1.93	20
2019-20	6	20	25	2	67500	135231	67731	2.00	20
2022-23	4	20	30	2	120000	238140	118140	1.98	20
Total	-	-	195	-	-	-	-	-	138
Average	-	-	-	-	68756.71	137012.3	68255.5	1.99	-

E. Impact

Backyard Poultry Farming (BPF) adoption rate itself explained that more that 70 percent farmers are showed their kin interest in this venture. Presently Farmers of more than 15 villages namely Baidibagar, Kholseer, Sainj, Karalagaon, Okhalisirod, Pasdev, Gairigar, Kangar, Matella, Kafligair, Chhauna, Billori, Naghar, Krasibunga, Kisrauli etc were covered under Backyard Poultry Farming (BPF) demonstrations. We hope more no. of farmers of other villages of district Bageshwar will be added in this venture in coming days.

F. Marketing

In hills there is ample scope of selling egg and meat of poultry. Presently selling price of egg is Rs.10-12 per egg and chicken Rs. 240-260 per kg. Hence interested poultry farmers can earn huge amount by selling eggs and chicken.

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UNRAVELING THE VITAL ROLE OF ENDOPHYTES IN SUSTAINING PLANT HEALTH

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Introduction

In the twentieth century, agricultural intensification relied on advanced machinery, tillage, high-yield varieties, and heavy chemical inputs (Foley *et al*., 2005). However, these methods harmed soil and human health, reducing fertility and increasing pest resistance. Alternative approaches are now necessary to sustainably manage agricultural production against abiotic and biotic stresses. Microorganisms, particularly plant endophytes, have gained attention for enhancing plant health and disease management (Singh *et al*., 2011; Jha *et al*., 2013). Endophytes inhabit healthy plant tissues without causing apparent disease symptoms and contribute to soil fertility and phyto-remediation. The term endophytes are coined by Anton de Bary in 1866, it refers to microorganisms residing within plants. They inhibit pathogens, enhance plant physiology, and induce resistance mechanisms while improving soil fertility. Although endophytic bacteria are widespread among plants, discerning their benefits amidst other rhizospheric microbes remains challenging. As such, they hold potential as biocontrol agents against plant diseases because they are able to colonize the same ecological niche favoured by many invading pathogens. Depending on the species and the interaction, endophytes may be located in roots, leaves or needles, shoots, or adapted to growth within the bark (Grunig *et al.* 2008; Rodriguez-Cabal *et al.* 2013). The economic and environmental benefits of leveraging endophytes in plant disease management to sustainably enhance agriculture and agri-food production. Endophytes, residing within plant tissues, offer immediate protection against abiotic and biotic factors, mitigating substantial side effects. Through the production of diverse allelochemicals and secondary metabolites, endophytes suppress phytopathogen growth and confer systemic resistance to plants. The synergistic effects of endophytes with commercial pesticides present promising avenues for combating multiple diseases in changing climate scenarios. Their potential as biocontrol agents positions them as viable alternatives to agrochemicals and fungicides, with volatile organic compounds exhibiting inhibitory effects on phytopathogens.

Endophytes, with a history spanning over 400 million years, have been closely linked to terrestrial plants since ancient times (Krings *et al*., 2007). They are now found in diverse plant habitats, ranging from ferns and lichens to shrubs and trees, contributing significantly to various ecosystems (Sun and Guo, 2012). Their importance became apparent historically when toxicosis in cattle was linked to the consumption of *Festuca arundinacea* grass infected with *Neotyphodium coenophialum*. The first isolation of endophytic fungi was reported by Petrini and Dreyfuss (1981) from plants of different families. Despite variations in abundance across hosts, at least one endophytic fungus species has been identified in every plant investigated (Faeth and Fagan, 2002). Bacterial endophytes are believed to originate from the microflora of the rhizosphere and phyllosphere (Sturz and Nowak, 2000). They colonize internal plant parts like xylem tissues without causing harm to the host plant (Schulz and Boyle, 2006).

Types of endophytes

Endophytic bacteria and fungi actinomycetes, and mycoplasma, inhabit plant tissues intracellularly or intercellularly, can promote plant growth and yield, can act as biocontrol agents. Endophytes can also be beneficial to their host by producing a range of natural products that could be harnessed for potential use in medicine, agriculture or industry (Ryan et al., 2008;Schulz and Boyle, 2005). In addition, it has been shown that they have the potential to remove soil contaminants by enhancing phytoremediation and may play a role in soil fertility through phosphate solubilization and nitrogen fixation (Ryan et al., 2008). There is increasing interest in developing the potential biotechnological applications of endophytes for improving phytoremediation and the sustainable production of nonfood crops for biomass and biofuel production.

Endophytes colonize on various plant parts without inducing visible symptoms and exhibit remarkable versatility in associating with multiple plant species. A single endophyte species can be found across diverse plants, while a host plant may host numerous endophyte species, either latent or interacting within the same plant. Over 200 genera across 16 phyla within the bacterial domain are known to associate with endophytes, with a majority found in *Actinobacteria, Proteobacteria,* and *Firmicutes* (Golinska *et al*., 2015). Notable bacterial genera, including *Achromobacter, Acinetobacter, Agrobacterium, Bacillus, Brevibacterium, Microbacterium, Pseudomonas,* and *Xanthomonas* have been identified as endophytes (Sun *et al*., 2013). These endophytic bacteria are recognized for their production of bioactive metabolites such as antimicrobial and antifungal compounds, exemplified by ecomycins and fusaricidins (Sun *et al*., 2013). Actinomycetes, members of the Actinobacteria phylum, are prokaryotic organisms characterized by their mycelium structure and spore-forming ability (Chaudhary *et al*., 2013; Barka *et al*., 2016). It has been documented that endophytic actinomycetes are capable of synthesizing various chemical compounds with significant medicinal properties.

Mechanism

In recent years, there has been significant research on endophytes due to their capacity to safeguard plants from diseases and mitigate plant damage. Endophytes achieve this by directly suppressing plant pathogens through the production of antibiotics, competitive mechanisms, and secretion of lytic enzymes. Nonetheless, it's crucial to note that these interactions are intricate and highly specific to the antagonistic relationship between different species. Numerous endophytes generate secondary metabolites with antifungal and antibacterial properties, effectively impeding the proliferation and progression of various microorganisms, including plant pathogens (Gunatilaka 2006). These antibiotics, which exhibit diverse chemical compositions such as alkaloids, terpenoids, polypeptides, and aromatic compounds, are detrimental to plant pathogens. For instance, when *Chaetomium* and *Phoma* were introduced into wheat, they mitigated the severity of foliar disease induced by *Puccinia* and *Pyrenophora* spp.

Certain endophytes have the potential to act as mycoparasites. For instance, *Acremonium strictum* W. Gams, an endophyte commonly found in *Dactylis glomerata* L. and various other grasses (Sánchez Márquez *et al*., 2007), has been identified as a mycoparasite of *Helminthosporium solani* Durieu and Mont., a pathogen affecting potatoes. A fungal endophyte, *Fusarium solani*, isolated from the root tissues of tomatoes, has been found to induce systemic resistance against the foliar pathogen *Septoria lycopersici*. This is achieved by activating the expression of PR genes, specifically PR5 and PR7, in the roots (Kavroulakis *et al*., 2007). Additionally, plants hosting endophytes exhibit a swifter initiation of defense responses compared to those without endophyte colonization. The mechanism by which endophyte elicitors induce resistance in plant secondary metabolites resembles the process of stimulating plant resistance itself. Fungal endophytes prompt the release of plant cell hydrolases to restrict fungal growth, leading to the generation of endophyte fragments that serve as elicitors. These elicitors then activate plant defense mechanisms and the production of secondary metabolites, aiding in the effective suppression of pathogen attacks (Yong *et al*., 2009).

Lu et al. (2000) observed that *Colletotrichum* sp., an endophytic fungus, synthesized growth-regulating substances, including indole acetic acid (IAA), which contributed to the regulation of various plant processes. Similarly, *Fusarium* sp. was found to produce an E5 extract with auxin-like properties (Dai *et al*., 2008). As defense responses demand significant energy, endophytes are thought to provide reducing equivalents and carbon skeletons through primary metabolic pathways (Bolton 2009). It is reasonable to infer that enhancing plant growth could result in increased plant protection against pathogens. Additionally, volatile compounds like 2,3-butanediol and acetoin, produced by bacteria, have emerged as a novel mechanism for promoting plant growth (Ryu *et al*., 2003).

Endophytes may possess the ability to directly inhibit pathogens by producing antifungal or antibacterial compounds. For example, the endophytic bacterium *Bacillus pumilus* (JK-SX001) is particularly efficient at reducing the infection rate and severity of canker caused by three pathogens (*Cytospora chrysosperma, Phomopsis macrospora* and *Fusicoccum aesculi*) in Poplar cuttings. This *Bacillus* strain produces a combination of extracellular enzymes (including cellulases and proteases) and other secondary metabolites that are thought to inhibit the mycelia growth of the pathogen (Ren *et al.* 2013). In another study, the pathogen *Phytophthora meadii*, which causes abnormal leaf fall of rubber trees (*Hevea brasiliensis*), was suppressed using the endophytic bacterium *Alcaligenes* sp. (EIL-2) isolated from healthy rubber tree leaves. In dual cultures, *Alcaligenes* sp. (EIL-2) produced a substance that inhibited hyphal growth of the pathogen. When the endophyte was applied as a foliar and soil drench to one-year old greenhouse plants prior to infection by the pathogen, infection rates were reduced by more than 50% (Abraham *et al.*2013).

Conclusion

Scientists are increasingly studying endophytes as biocontrol agents for plant diseases. Endophytes' explores potential mechanisms against plant pathogens, considering both direct and indirect effects, and their ecological implications. Given the high costs and environmental concerns of chemical inputs, endophytes offer promise for sustainable agriculture if effective inoculants are developed. The apparent interest in the endophyte communities in the endospheres, phyllospheres and rhizospheres of plants reflects the increasing interest in the potential of endophytes to modify, influence and affect the biotic and abiotic stress tolerance of their hosts through several mechanisms. In recent years Endophytes received considerable attention due to their envisaged potential as a source of novel and unique bioactive chemicals to be exploited for forestry, agricultural, pharmaceutical and industrial purposes. These observations highlight the fact that there are still gaps in our knowledge on how the complex interactions that exist in different ecosystems with respect to fungal endophyte composition, nutrient availability, and host interaction could be harnessed for the benefit of plants. The biggest challenge is to link the acquired novel knowledge on microbiomes to translational forest management for the benefit and improvement of forest health. In the long term, this will facilitate policy and decision making in plant health management.

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BUNCH MANAGEMENT IN BANANA FOR HIGH QUALITY FRUIT PRODUCTION

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Introduction

Banana (*Musa paradisiacal* L.) is the largest herbaceous perennial plant belongs to the Musaceae family in the order Zingiberales (Sora and Merga, 2023). It is one of the major fruit crops grown in tropical and subtropical regions of the world, and originated from the tropical region of South-East Asia. Bananas are symbol of prosperity and fertility and the plant is also referred as "Apple of Paradise" or "Kalpataru". There are around 300 varieties of bananas cultivated around the globe. However, there are only 20-25 varieties of bananas are commercially cultivated in different parts of India. Among them Grand naine (AAA) occupied more than 50% cultivated area owing to its high yield, long shelf life and universal acceptance of consumer.

Nutritionally bananas are rich source of potassium (368 mg) and energy 350-550 kilo Joules/100g. Lutein & Dopamine in the bananas act as antioxidants. "Karat" banana belongs to Fei banana group in the island of Micronesia, contains 2230 µg/100 g, 100 times the carotene content of the common Cavendish banana (21 µg/100 g). Ripe fruits of *Musa* cv. Bhimkol could meet 100% RDA of K, Zn, Mn and S for 6 months old infant.

Global banana production increased from 69 million tonnes in 2000-2002 to 155.22 million tons in 2017-2021, with a value of around 40 billion USD (FAOSTAT, 2023). India ranks first in banana production, with 34.52 million tons in an area of 962.6 thousand ha having a productivity of 35.9 t/ha accounting for 19.85% of global output (Ramanandam *et al.*, 2023). Among the major banana growing states (A.P, MH, Gujarat, TN, KA, UP etc.,), Andhra Pradesh stands first with 5.68 million tonnes from 1.09 lakh ha. Having 16.5% share. Despite of its higher production, the export of fruits are very much limited owing to non-following of some of the important operations in banana cultivation. External and internal appearance and market quality of bananas are influenced by several factors, including pre-harvest production practices. The external appearance includes key attributes such as colour, shape, size and freedom from defects. The internal attributes such as taste, texture, sweetness, aroma, acidity, flavour, shelf life and presumed nutritional values of the fruit are important in ensuring repeat buys for sustained repeat purchase (Shewfelt, 2009). The physical appearance of the peel is especially important in the highly competitive export markets and in some local supermarkets (Shewfelt, 1999). Buyers in these prime markets require consistent supplies of uniform coloured fruit with blemish-free peels.

Special cultural practices to be followed in banana

- ✓ Desuckering
- ✓ Mulching
- ✓ Propping
- ✓ Pruning of Leaves
- ✓ Removal of withered styles and perianth
- ✓ Bunch covering
- ✓ Denavelling
- ✓ Banana bunch feeding
- ✓ Bunch/finger thinning
- ✓ Banana bud injection
- ✓ De-fingering
- ✓ Foliar nutrition
- ✓ Peduncle wrapping and Bunch sprays

Desuckering:

Basically, banana producefour types of suckers as fallows.

- ➢ **Sword sucker** (follower) - young sucker, narrow leaves with larger corm size (250 to 350g).

- **Water suckers** - small suckers of superficial origin with broad leaves andsmaller corm size which are unsuitable for followers/propagation and should be removed.
- **Maiden sucker-**A large but non-fruiting ratoon.
- **Peeper-**Avery young sucker bearing scale leaves, appears above the soil.

Removal of surplus and unwanted suckers from banana plant is known as desuckering.When the banana plant grows to a certain size, many suckers, that are derived from axillary buds, sprout from the rhizome (also known as the corm) of the mother plant (6–8 suckers per plant). The suckers consume nutrients; reduce vigour; and delay budding, shooting, and fruiting of the mother plant, which undermines fruit yield and fruit quality (Chundawat and Patel, 1992). Suckers are removed from the mother either by cutting the sucker at ground level or by destroying the heart of the suckers without detaching the sucker from the plant. Desuckering can also be achieved by pouring kerosene oil (5-10ml/sucker)/2, 4-D @ 0.5 per cent into the heart of the sucker. A mixture of KH_2PO_4 (KDP) and paclobutrazol (PBZ) 2:1 ratio can effectively remove banana suckers while improving fruit yield and the quality of the mother plant (Luo *et al.*, 2020).

Fig. 1. **Arrows in B indicate growth points that remained fresh and showed normal morphology. Arrows in D indicate growth points that had rotted and disintegrated, with no signs of regrowth**.

Mulching

A mulch is a layer of material applied to the surface of soil, which helps in conserving the soil moisture, increasing the number of feeder roots and thereby improving the nutrient and water use efficiency. Further, it suppress weed growth and thereby enhances the banana yield by 30-40%. The disease severity (internal corm discoloration), was reduced from 90% to 37% when

Eucalyptus cloeziana leaves used as mulch which contain very high concentration of tasmanone which is the primary oil constituent of Eucalyptus leaves (Ryan and Paul, 2021). 100 µ polythene mulches and weed mats can also be used as mulch material for banana cultivation.

Propping:

Propping is a cultural practice carried out on banana plants to provide additional support for the plant when it carries heavy loads (fruits) during bunching.Tall varieties viz. Karpura Chakkerakeli (AAB), Tella Chakkerakeli (AAA), Mortaman (AAB), Kovvur Bontha (ABB), Godavari Bontha (ABB) etc., which produce heavy bunches need propping. While, the short statured cultivars like Kaveri Kalki (ABB), Dwarf Cavendish (AAA), TBM-9 (AAA), Phule pride (AAA) etc., does not required propping. Bamboo poles are commonly used for propping which has effective life of 3-4 years.Eucalyptus or Casuarina poles can also be used as an alternative to bamboo but their economic life is only 1 to 2 years. Coir or polythene rope can also be used for propping.

A. Propping with bamboo poles B. Mulching with Polyethylene

Pruning of leaves (Trashing):

The process of removal of undesirable material from the banana plant like dried, diseased and decayed leaves is known as trashing. This operation helps to prevent senescent leaves from hanging over suckers, reduce disease spread and prevents fruit scarring.Ensure there should be at least 12 to 13 healthy leaves remaining on the plant at shooting to bunch development stage. Proper care need to be taken while trashing and avoid severe leaf removal or damage for better bunch weight, yield and quality fruits.

Removal of withered styles and perianth:

In some varieties the styles are persistent and hence they remain in the bunch till maturity. They can be easily removed by a light brushing movement of the hand a few days after flowering and if it is delayed, it is difficult to remove and later they become brown and shrivelled. This operation eliminates the removal of infection by saprophyte fungi especially to avoid the finger tip disease.

A.Trashing **B.**Styles and Perianth removal

Bunch covering

Skirting of banana bunches during the pre-harvest stage helps to mitigate damage associated with physiological disorders arising from seasonal temperature changes, insect and pest infestation.Also helps to create better microclimate for fruit development, protects the fruit from sunburn, hot wind and dust.It is mostly practiced in Cavendish group and Nendran bananas to get attractive fruit colour..

Banana bunches covered with white transparent polythene covers and blue covers

The research results indicates when the bunches were covered with transparent polyethylene sleeves of 2% (cool season) or 4% (summer season) ventilation immediately after opening of the last hand - increased yield by 15-20 %, early bunch maturity by 15-20 days, reduce the blemished fruits by 15-20% with attractive fruit colour in all the commercial varieties viz., Karpura Chakkerakeli, Tella Chakkerakeli, Robusta, Kovvur Bontha and KBS-1 over that of uncovered bunches. Now a days 17 GSM white U.V. resistant non-woven fabric materialsare popularly using as bunch skirting material. 1000 m. role is sufficient for one acre banana

Denavelling

The part of the inflorescence which consists of male flowers only, is termed as male budor navel.The process of removal of male bud after completion of female phase is termed as ‘denavelling’. This checks the movement of photosynthates into the unwanted sink and promotes better fruit development.In bananacv.KarpuraChakkarakeli (AAB)denavelling12-15 days after last hand openingresulted in increasedfruit size (length and girth), mean bunch weight (0.9kg) and yield (7.5%).

Banana bunch feeding

This ICAR-IIHR technology enhances the bunch yield and fruit size. The technique involves blending of 7.5g Urea + 7.5 g SOP dissolved in 100 ml water in 500 g of fresh cow dung and applying the slurry to the de-navelled stalk-end soon after fruit set. The technology is cost effective as the cost involved is about Rs. 2/- per bunch while the improvement is of 4-5 Kg of ‘Robusta’ and 2-3 Kg of ‘Ney Poovan’ Banana Bunch.

Banana bud injection

The banana flower thrips, *Thrips hawaiiensis* (Thysanoptera: Thripidae), is one of the most common flower-dwelling thrips worldwide (Mound, 2005) which live and breed in the male buds in large numbers leading to fruit damage (brown freckling) resulting unattractive poor quality fruits. Hence, it is quite difficult to control this thrips mainly due to its rapid population increase during the flowering season (Fu *et al*. 2019). Systemic insecticides can be rapidly absorbed by the plant and translocated throughout its tissue, making plant tissues toxic to the target pests in an efficient and environment friendly way. Among systemic insecticides, the imidacloprid is the most promising and has been widely used in injection systems, as it has high efficacy against numerous pests. To overcome this problem, bud injection with imidacloprid 17.8 SL (imidacloprid 0.3ml in 500ml of water) @ 1ml/bud injected at 1/2 or 3/4th emerged inflorescence at upright position 6 to 8 inches below the bud tip at an angle of 40 degrees. The mean per cent infestation was reduced by about 10% in plant and ratoon crops in banana cv. KarpuraChakkerakeli (AAB).

A. Control **B.** Bud injection imidacloprid 17.8 SL

Bunch thinning & De-fingering

One to two small bottom hands should be removed from the bunch in order to facilitate uniform bunch development, while defingering is the practice of removing deformed or excess fingers to obtain the good shape of the banana hand.

Peduncle wrapping

The peduncle is the main - nutrient, photosynthate, water conducting bridge between the developing bunch and the plant. During bunch maturation period, due to bright sunshine, there are possibilities of scorching injury on peduncle. This will pave way for secondary infection by any fungi or bacteria. Once the peduncle gets affected, the nutrient, photosynthate and water flow from plant to developing bunch will be arrested and it will lead to immature ripening or immature falling of the bunches. So during peak summer, banana bunch peduncle exposed to scorching sun should be wrapped with flag leaf or banana leaf trashes.

Sun burn on peduncle

Foliar nutrition

Foliar application of nutrients provides quick and effective augmentation of nutrients and may prevent hidden hunger when properly timed. In banana particularly at reproductive stage, high nutrient availability is important to support plant requirements until harvest, since large quantities of photosynthetic are beginning to move from the source to the sink (developing fruit bunches).Any limitation in the supply of nutrients at this stage will negatively affect bunch size and fruit quality. However, it has not been wise to apply fertilizers basally at finger development stage, since the uptake is slow and low.

Research at Dr. YSRHU-HRS, Kovvur revealed that, foliar spray of $ZnSO_4$ (0.2%) + H_3BO_3 (0.2%) + $FeSO_4$ (0.2%) recorded higher yield (40 t/ha) in banana cv. Martaman. The fruits had longer shelf life of 6 days and were with higher total sugars and lower percentage of lumps.

Foliar spray of IIHR-Arka banana special or NRCB-banana Shakti also increasing the productivity by 15-20% and quality attributes TSS of fruit by 2.4 ^{o}Brix and decreases the acidity of fruit by 0.03% in Ney Poovan banana leading to improvement in fruit taste, sweetness, flavour and aroma

Banana bunch sprays

Among all the nutrients, banana requires high potassium for proper finger filling and bunch development. Foliar spraying of Pottasium nitrate (13-0-45) @ 5g/litre of water along with 0.5ml gum/surfactant at five days after last hand opening followed by spraying with SOP (sulphate of potash; 0-0-50)@10g/lit at 15th day improves the finger quality and bunch yield. Similarly spraying with Potassium di hydrogen orthophospate @ 5g/lit along with 0.5ml gum/surfactant during winter season at 7-10days interval will help to overcome the pre-mature ripening of fruits.

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VERMICOMPOST TECHNOLOGY AND ITS USES

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Abstract

Vermicomposting is a type of composting in which certain species of earthworms are used to enhance the process of organic waste conversion and produce a better end-product. It is a mesophilic process utilizing microorganisms and earthworms. Earthworms feeds the organic waste materials and passes it through their digestive system and gives out in a granular form (cocoons) which is known as vermicompost.

Key words: Vermicompost, earthworms, production, application and benefits

Introduction

Vermicompost is earthworm excrement, called castings which can improve biological, chemical and physical properties of the soil. The chemical secretions in the earthworm's digestive tract help break down soil and organic matter, so the castings contain more nutrients that are immediately available to plants.

Production

spacious mixture of organic residues, such as straw, husk, leaves, stalks, weeds, livestock wastes, poultry litter, dairy wastes, bagasse and Earthworms consume organic wastes and reduce the volume by 40–60 percent.

Each earthworm weighs about 0.5 to 0.6 gram, eats waste equivalent to its body weight and produces cast equivalent to about 50 percent of the waste it consumes in a day. The moisture content of castings ranges between 32 and 66 percent and the pH is around 7.

The level of nutrients in compost depends upon the source of the raw material and the species of earthworm.

A nearly 3600 types of earthworms which are divided into burrowing and non-burrowing types. Red earthworm species, like *Eisenia foetida,* and are most efficient in compost making. The non-burrowing earthworms eat 10 percent soil and 90 percent organic waste materials, these convert the organic waste into vermicompost faster than the burrowing earthworms. They can tolerate temperatures ranging from 0 to 40°C but the regeneration capacity is more at 25 to 30°C and 40–45 percent moisture level in the pile.

The burrowing types of earthworms come onto the soil surface only at night. These make holes in the soil up to a depth of 3.5 m and produce 5.6 kg casts by ingesting 90 percent soil and 10 percent organic waste.

The types of vermicomposting depend upon the amount of production and composting structures. Small-scale vermicomposting is done to meet personal requirements and farmers/gardeners can harvest 5-10 tons of vermicompost annually. On the other hand, large-scale vermicomposting is done at commercial scale by recycling large quantities of organic waste in modern facilities with the production of more than hundreds of tons annually.

Applications

The worm castings contain higher percentage of both macro and micronutrients than the garden compost. Apart from other nutrients, a fine worm cast is rich in NPK which are in readily available form and are released within a month of application.

Benefits

- Enhances plant growth, suppresses disease in plants, increases porosity and microbial activity in soil and improves water retention and aeration.
- Benefits the environment by reducing the need for chemical fertilizers and decreasing the amount of waste going to landfills.

- Vermicompost tea which is a liquid formed by extracting organic matter, microorganisms and nutrients from it and when the same is applying to the soil as a supplement, it increase biological activity between compost applications.
- It can be used in the form of liquid organic fertilizer and when applied directly to plant foliage, it enhance disease suppression.

Method of sales

- It may be sold either in bulk or bagged with a variety of compost and soil blends.
- It may be available from home improvement centers, nurseries, landscape greenhouses, garden supply stores, grocery chains, flower shops, discount houses and the general public.

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SUGARCANE GROWTH IN DIFFERENT STAGES

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Abstract

Sugarcane, a sweet reed had attracted many from monks to monarches. Sugarcane is the most efficient converter of solar energy in to stored energy. It was programmed to study the growth (leaves and stem (internodes) of sugarcane at monthly interval up to harvest. The study specifically focused on sett development in number at different growth stages. One plant was tagged and observed continuously for number of leaves and setts produced. At 30 DAP only leaves emerges (6 leaves) and the leaves to the maximum number of 13 until harvest. If we observe the important phenomenon number of setts, the sett started to emerge on 90 DAP and increased to 7 on 120 DAP and 10 on 150 DAP and 17 on 180 DAP. 150-180 DAP is the critical phase on which more number of setts were grown 120-180 DAP is the crucial phase for sett development.

Introduction

Sugarcane, a sweet reed had attracted many from monks to monarches. The word Saccharum seems to be originate from Sanskrit word sarkara. The most ancient reference to sugarcane is in Atheravaveda which is 5000 years old. In budhist literature, Gautama , the Budha was known as “king of sugarcane’’. It is a common truism that sugarcane is the most efficient converter of solar energy in to stored energy. Photosynthate mobility was higher in thick and long internodes. The optimum temperature is 30 to 32^{0}C while growth is restricted below 14^{0}C.

sugarcane is grown in areas where the average rainfall is about 500 and 2500 mm. it requires lot of sunshine during the growth period. There are three distinct planting periods of sugarcane.

Season

Seasonal – Jan – Feb,

Preseasonal or autumn planting – October – November,

Adsali – June – July (18 months crop).

Production

In Agriculture sector, sugarcane share is about 7% of total agriculture production and occupied 2.6% of India's gross cropped area with functioning of 527 sugar factories. India occupies an important place among the sugarcane producing country and has a neck to neck race with Brazil. Sugarcane is cultivated in an area of 4.44 mha in India with the annual production of 306.07 lakh tonnes and cane productivity of around 69.0 t/ha with an average sugar recovery of approximately 10% (ISMA, 2019).

Growth of sugarcane

It was programmed to study the growth of sugarcane at monthly interval up to harvest. Tillering is not observed in this study. The study specifically focused on sett development in number at different growth stages. One plant was tagged and observed continuously for number of leaves and setts produced. At 30 DAP only leaves emerges (6 leaves) and the leaves to the maximum number of 13 until harvest. If we observe the important phenomenon number of setts, the sett started to emerge on 90 DAP and increased to 7 on 120 DAP and 10 on 150 DAP and 17 on 180 DAP. 150-180 DAP is the critical phase on which more number of setts were grown 120-180 DAP is the crucial phase for sett development.

Number of internodes was maximum to 38 here in this study only 17 internodes were developed and the number of internodes was distinctively given at 30 days interval. This will clearly pictured out the stage of grand growth phase in sugarcane. The number of internodes varied with varieties and environment in which it grows.

The growth stages of sugarcane is grouped in to Tillering phase (36 to 100 days) , Grand growth phase (101 – 270 days) and Maturity phase (271 - harvest). Adequate care is required at 120 DAP and grand growth phase extended up to 270 days.

Table 1. Number of leaves and internodes in sugarcane at monthly interval

Tillering phase			Grand growth phase						Maturity phase	
30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	240 DAP	270 DAP	300 DAP	330 DAP
6 leaves	8 leaves	8 leaves	13 leaves	13 leaves	13 leaves	13 leaves	13 leaves	13 leaves	13 leaves	13 leaves
-	-	1 sett	7 Setts	10 setts	17 setts	17 setts	17 setts	17 setts	17 setts	17 setts

Conclusion

The number of internodes varied with varieties and environment in which it grows. The sett (internodes) started to emerge on 90 DAP and increased to 7 on 120 DAP and 10 on 150 DAP and 17 on 180 DAP. 150-180 DAP is the critical phase on which more number of setts were emerged. 120-180 DAP is the crucial phase for sett development. Number of internodes was maximum to 38 here in this study only 17 internodes were developed.

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YIELD DECLINE IN RATOON (YLD) AND HAS RECORDED LESS SPAD VALUE THAN PLANT CANE

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Abstract

Sugarcane yields are known to decline with successive ratoon crops, a phenomenon termed ratoon yield decline (RYD), and the rate of decline is largely dependent on the environment in which the crop grows. Environment in which sugarcane grows largely decides the yield if the factors responsible for yield decline is identified, can assist growers manipulate them through best practices to attain longer profitable ratoon cycles. RYD is defined as the reduction in yield with successive ratoon crops within a cropping cycle (comprising a plant crop and ratoon crops, while YD (Yield decline) is the loss of productive capacity of sugarcane soils under long-term monoculture. ratoon has recorded lesser (41.7) SPAD value (correlation of chlorophyll concentration in leaf) than plant cane crop (79.9).

Introduction

Sugarcane is one of the commercial and industrial crops of India shares major hold in Indian economics. Sugarcane yields are known to decline with successive ratoon crops, a phenomenon termed ratoon yield decline (RYD), and the rate of decline is largely dependent on the environment in which the crop grows. An environment in sugarcane production is characterized by harvest season and soil type, and gaining an understanding on how these influence RYD, can assist growers manipulate them through best practices to attain longer profitable ratoon cycles. If factors leading to ratoon yield decline (RYD) were to be identified and best practices be adopted to reverse their long-term effects, the general decline in sugarcane yield can be moderated. RYD is defined as the reduction in yield with successive ratoon crops within a cropping cycle (comprising a plant crop and ratoon crops, while YD (Yield decline) is the loss of productive capacity of sugarcane soils under long-term monoculture. Well structured and good draining soils have longer ratoon crops than poorly structured soils. Sandy soils (i.e., light structured sand and sand loam soils) are porous, characterized by poor water and nutrient retention. Literature says that at São Luiz mill in Brazil, volcanic soils produced eight crops with an average cane yield of 110 tons per hectare while sandy soils produced six crops with an average cane yield of 80 TCH. In contrast, duplex soils (i.e., heavy structured clay and silty clay soils) are prone to waterlogging which often leads to salinity and sodicity problems in agricultural systems. Scientists observed a rapid yield decline in clayey soil averaging 6% between ratoon crops over five viable crops while red oxisols only declined by 2% between crops over eight viable crops.

Climate

Sugarcane originated from the tropics and requires a warm climate, and only when the temperature is above 20 °C can the mean effective accumulated temperature meet the requirement for sugarcane normal growth and development. Previous data also suggest that the non-optimum germination or sprouting temperatures, too low or too high, may be a factor for yield decline in ratoon cane. Compared with plant cane, ratoon plants have an established, and strong root system, representing the unique skeleton of carbon and energy source for the initial plant development.

Growth of Sugarcane

The root system, which is essential for regrowth of sugarcane and the ratoon vigor of each cycle, can be used for water transport to leaves during the period of photosynthesis, in which photosynthetic products are accumulated and in turn promote a rapid leaf expansion and plant growth during the early growing stage. Therefore, ratoon plants have more effective accumulated temperature and longer effective growth period, resulting in more sugar accumulation and earlier technical maturity.

In contrast, newly planted sugarcane plants firstly need to grow roots, especially permanent roots, which requires a relatively longer period and a higher effective accumulated temperature. As a result, the newly planted sugarcane does not use light and thermal sources efficiently at this stage. Therefore, from the perspective of energy utilization, ratoon sugarcane has a significant energy-saving characteristic. According to published reports, ratoon sugarcane requires only 89,040,000 calories per ton of sugarcane production, while newly planted sugarcane requires 204,550,000 calories per ton, suggesting that plant cane uses 2.3 times more calories than ratoon cane. An irrigated ratoon crop requires only 295 days for its maturity compared with 365 to 482 days in plant cane.

Table 1. Ratoon cycles adopted in different countries

Country Name	Ratoon Percentage (%)	Ratoon Age (Year)
America	80–85	2–3
Brazil	80–90	4–5
Australia	80–85	2–3
South Africa	80–90	4–5
China	50–70	2–3
India	>50	1–2
World	75	4–7

It is widely accepted that variations in ratooning ability exist in different genotypes and hybrid offspring. We have recorded the SPAD values of directly planted and ratoon crops of aged 6 months as ratoon requires more nitrogen for growth and development.

Table 2. SPAD values of main and ratoon on 6 months after planting /ratooning

SPAD value of main crop	79.1
	79.1
	81.4
Mean	79.9
SPAD value of ratoon crop	43.7
	34.7
	46.9
Mean	41.7

Clearly implies that ratoon has recorded lesser (41.7) SPAD value (correlation of chlorophyll concentration in leaf) than plant cane crop (79.9). Hence additional nitrogen recommendation of nitrogen is made for ratoon crop to meet out the requirement and as yield as plant cane crop.

Conclusion

Many factors responsible for yield reduction in ratoon mainly depends on the soil in which it grows. Here one of the factor is identified that is lesser SPAD value which is directly correlated with the chlorophyll content. The uptake and soil availability is differed between plant cane and ratoon cane. SPAD value was 41.7 in ratoon cane as against the SPAD value of 79.9 in plant cane which showed the difference in growth and development of cane in plant cane and ratoon cane.

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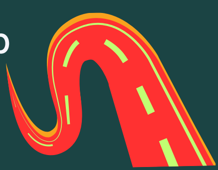

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