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FROM HARDSHIP TO HARVEST: THE INSPIRING JOURNEY OF SRI DAMODAR SAHOO IN MUSHROOM CULTIVATION

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Abstract

Sri Damodar Sahoo, a farmer from Odisha, overcame poverty despite limited education, and labour exploitation with his remarkable determination. Despite early hardships, he explored various income avenues, from running a betel shop to handmade goods. His life changed when he received support from the Horticulture department, gaining mentorship and trainings that led to the establishment of his mushroom farm. Sri Damodar's story showcases how personal resilience and timely government support can transform lives, inspiring rural entrepreneurs to pursue success through innovation and perseverance.

Introduction

Mushroom cultivation is an emerging practice that has gained widespread attention in recent years. These techniques offer promising solutions to address pressing environmental and agricultural concerns. Mushroom cultivation is not only a financially lucrative sector in agriculture but also nutritionally beneficial, offering health advantages for humans. "Determination turns obstacles into opportunities" – a statement proved true by Sri Damodar Sahoo, a resident of Radhabalavpur village, Bandhatia, under Dhamnagar block of Bhadrak district, Odisha. Overcoming numerous challenges, Sri Damodar achieved significant success in mushroom farming and is now setting his sights on even greater heights with his venture into vermicomposting as well. His journey reflects an inspiring tale of perseverance and ambition, transforming hardships into stepping stones for a prosperous future.

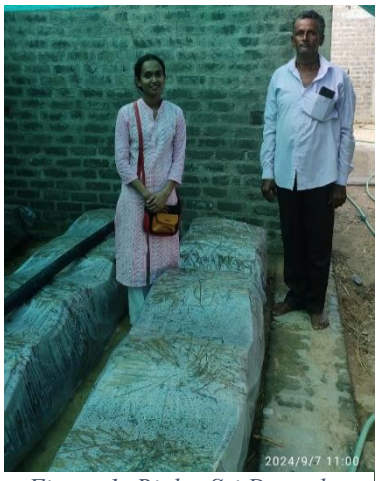

Figure 1: Right- Sri Damodar, Left- Miss Pooja

Overcoming Early Struggles and Challenges on the Path to Success:

Sri Damodar Sahoo, born in 1965, faced numerous challenges from an early age. His father, Sri Panchanan Sahoo, was a marginal farmer, and the family struggled with financial hardships. Due to these constraints, Sri Damodar was unable to complete his education and, as a result, did not pass his 10th-grade examination. Being the only son with three sisters to support, he decided to step up and contribute to the family's income. However, with limited education, securing a stable job proved difficult, forcing him to take up labour work. Unfortunately, during this period, he experienced mistreatment and exploitation from his landlords. Undeterred by these setbacks, Sri Damodar took a bold step towards self-reliance by starting a small betel shop. Alongside selling betel, he also crafted and sold handmade paper packets and even ventured into selling chicks. Despite his relentless efforts and hard work, financial stability remained elusive for him. However, his journey reflects the resilience and determination with which he faced life's adversities.

Fortune smiled on Sri Damodar Sahoo when he crossed paths with Mr. Surendranath Jena, a dedicated worker from the Udyana Bibhag (Horticulture department). Mr. Jena proved to be a life-changing influence, as he introduced Sri Damodar to Mr. Maheswar Chandra Rout, a senior authority in the horticulture department. Mr. Rout not only guided him on the importance of spirituality but also personally visited Sri Damodar's home, where he witnessed his family's difficult living conditions and showed genuine empathy. The very next day, Mr. Jena visited Sri Damodar's home with four bottles of mushroom spawn and gave him detailed instructions on mushroom bed preparation, encouraging him to begin mushroom cultivation. Interestingly, before receiving this guidance, Sri Damodar had already completed formal training in mushroom farming at OUAT in 1998 under the expert tutelage of Dr. Adaitya Kumar Patra. This combination of support and training set the foundation for Sri Damodar's journey toward success in mushroom farming.

Figure 2: Mushroom Bed made up of paddy straw, coconut frond and besan

He began his journey in mushroom cultivation by preparing beds using coconut, palm, and date frond, setting up his initial operations on the veranda of his home. However, he soon encountered significant challenges, particularly during the summer months when the lack of proper shade became a major obstacle. Additionally, his limited knowledge of disease management in mushroom farming posed difficulties. To overcome these issues, Sri Damodar took the initiative to visit several mushroom farms across Odisha, including Puri, Pipili, Dandamukundapur, and Raja Suna Khala. At these farms, he worked under experienced mushroom producers, gaining valuable insights into disease and nutrient management, which enhanced his farming skills.

Another major hurdle was the unavailability of mushroom spawn in Bhadrak, forcing Sri Damodar to travel to Bhubaneswar weekly, which was a financial strain given his modest means. Additionally, he had to cycle 50 km to sell his harvested mushrooms, adding to his challenges. Despite these difficulties, his determination and eagerness to learn helped him and gradually he started earning a decent income. He states, **"There was a time when I was chasing money, and now it's money that's chasing me."**

Achievements and Recognitions in Mushroom Cultivation:

Sri Damodar Sahoo's remarkable journey in mushroom cultivation has been recognized through numerous prestigious awards and honors:

- **2003**: Awarded the *Best Commercial Mushroom Cultivator* certificate under the Horticultural Programme at the Tyagabhumi Mahotsav, Bhadrak, Odisha.
- **2005**: Received the *Best Mushroom Cultivator* certificate at the district-level Krushi O Udyana Pradarshani Programme, Bhadrak, Odisha.
- **2007**: Honored with the *Top Spawn Producer and Mushroom Farmer* certificate and award at the district-level Krushi O Udyana Pradarshani Programme, with esteemed Sri Manmohan Samal, Revenue Minister of Odisha, as Chief Guest.
- **2009**: Recognized for *Excellence in Mushroom and Spawn Production* at the Kishan Mela, organized by the Krishi Vigyan Kendra, Bhadrak, Odisha.
- **2011**: Awarded the *Best Mushroom Farmer* certificate, a trophy, and a cash prize of Rs 5,000 by esteemed Sri Damodar Rout, Agriculture Minister of Odisha, at the state-level Krushaka Sanmana Mahoutsav, Odisha.
- **2014**: Sri Damodar was celebrated for his *Excellence in Scientific Knowledge in Mushroom Cultivation* and was recognized as the *Leading Mushroom Farmer* at the Aanchalika Krushi Mahoustav. This accolade underscored his deep understanding and application of scientific principles in mushroom farming.

Additionally, he was recognized for his *Successful Spawn Producing Unit and Mushroom Cultivation* with an award from the State Mushroom Grower Association at OUAT Bhubaneswar, Odisha. The Chief Guest of this event was Dr. Manjit Singh, Director of the ICAR-Directorate of Mushroom Research (DMR) in Solan, Himachal Pradesh.

These accolades highlight Sri Damodar's unwavering dedication and leadership in the field of mushroom cultivation. He states "**What once seemed impossible and daunting has now become a reality in my life. Through unwavering determination and relentless effort, I have been blessed to witness the fruition of my endeavors. I am profoundly grateful for the divine grace that has guided and enabled me to achieve these remarkable successes**."


Figure 3: Oyster mushroom

Training and Development Milestones of Mr. Damodar Sahoo:

- **1998**: Participated in a comprehensive training program on Mushroom Cultivation at the Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha. The training was conducted under the esteemed guidance of Dr. Aditya Kumar Patra, laying the foundation for Mr. Sahoo's expertise in mushroom farming.
- **2004**: Attended advanced training on Mushroom Spawn Production at the National Institute of Mushroom and Biological Science, Bhubaneswar, Odisha. This equipped him with specialized knowledge in mushroom spawn production, a crucial aspect of commercial mushroom cultivation.
- **2009**: Received further training on commercial mushroom cultivation at the Krishi Vigyan Kendra (KVK), Bhadrak, Odisha, enhancing his understanding of large-scale mushroom farming techniques.
- **2010**: Participated in an intensive training program on organic farming under the National Project on Organic Farming, organized by the Horticultural Department of the Government

of Odisha. This training included insights into mushroom farming in polyhouse environments during winter seasons, along with the production of value-added mushroom products.

- **2011**: Gained specialized knowledge in milk mushroom farming through targeted training sessions. During the same year, he attended the "Chuchi" mushroom book presentation program, conducted in Baripada and organized by NABARD, further expanding his expertise in the field.
- **2012**: Participated in Interstate Agriculture Training cum Exposer Visit Programme of Bhadrak, Odisha. Where they visited New Delhi, Himachal Pradesh, and Haryana under the ATMA scheme. The visit was organized by the Centre for Agriculture and Rural Development (CARD), New Delhi and Financially supported by ATMA. During this tour, he explored the cultivation of Button and Milk Mushrooms and gained deeper knowledge about mushroom compost production methods.

This progression of training highlights Sri Damodar's dedication to mastering mushroom cultivation, making him a leader in the field.

Financial Support and Earning Journey:

In 2007, through the guidance of former Deputy Project Officer of Bhadrak, Mr. Sudarshan Parida, a subsidy loan of ₹25,000 was secured under the Government's Sampoorna Grameen Rozgar Yojana (SGRY). This initial financial support marked the beginning of an ambitious journey in agriculture. By 2010, further efforts were made to expand the business, resulting in the approval of a subsidy loan amounting to ₹5 lakhs under the National Horticulture Board Scheme. This opportunity was made possible through the assistance of Mr. Dilip Kumar Khuntia, Deputy Project Officer of Bhadrak. However, despite the availability of the scheme, the loan request was initially rejected by UCO Bank, Dhamnagar, due to the lack of collateral. It was with the support of Mr. Santosh Kumar Padhi, the Village Level Worker (VLW) of Bhadrak, who stepped in as a guarantor, that the financial assistance was finally secured. With this capital, the farm was significantly expanded, leading to a substantial increase in mushroom production. Initially, daily production was limited to around 7-8 kgs, yielding a monthly income of approximately ₹10,000-15,000. However, through his dedicated efforts and continuous training, production levels rose to 60-70 kgs per day. Additionally, by sourcing 2-3 quintals of mushrooms per day from nearby small-scale producers, and selling them across various districts, a commission of ₹5 per kg was set by him. This additional revenue stream earned ₹1,000-1,500 per day in commissions, resulting in a monthly income ranging from ₹90,000 to ₹1 lakh.

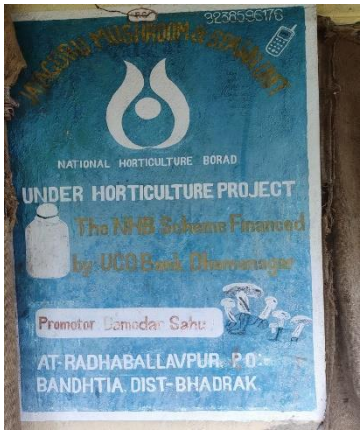

Figure 4: Mushroom and Spawn producing Unit under NHB scheme

Table 1: Comparison of Production and Income details Before and After NHC scheme

Category	Before	After	% Increase
Mushroom Production (kg/day)	7-8	60-70	757.14%
Monthly Income including Commission	₹10,000-15,000	₹90,000- 1lakh	800%

This success story is a testament to the power of perseverance, financial support, and effective collaboration in agriculture's future.

Conclusion

Sri Damodar Sahoo's journey is a remarkable tale of resilience and determination. Despite early financial hardships and limited education, he overcame adversity through hard work and strategic support. Introduced to mushroom cultivation by Mr. Surendranath Jena and backed by training from experts, Sri Damodar steadily grew his small operation, overcoming challenges such as disease management and spawn shortages. With government loans and key support from figures like Mr. Santosh Kumar Padhi, he expanded his production from 7-8 kgs daily to 60-70 kgs, earning a substantial income.

His success didn't stop with mushroom farming. Inspired by sustainability, Sri Damodar ventured into vermicomposting, using mushroom farm waste, banana plant biomass, aquatic weed (Ghoda dala), cow dung, and red earthworms (*Eisenia fetida*) to produce organic compost. He also began earthworm multiplication and sales, further diversifying his business.

Figure 5: Vermicompost Unit of Sri Damodar

From a modest start, Sri Damodar's story highlights how perseverance and innovation can lead to tremendous success, inspiring others to pursue opportunities for growth.

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ALOE VERA GEL AS AN EDIBLE COATING

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ABSTRACT
Several materials can be used to produce edible films/coats; however, these days, bio-based, cost-effective, and sustainable coatings have gained a high reputation. For instance, Aloe vera gel (AV) is a promising bio-based material for edible coatings and films. *Aloe vera* gel has been proven to be one of the best edible and biologically safe preservative coatings for different foods because of its film-forming properties, antimicrobial actions, biodegradability and biochemical properties. It acts as a semipermeable barrier for gases and water vapor, which reduces the respiration and ripening processes of the fruit. This helps maintain the fruit's weight, firmness, and valuable compounds. Additionally, its antioxidant and antimicrobial properties make it a valuable material for extending the shelf-life of fruits and vegetables.

Keywords: *Aloe vera* gel, edible coatings, shelf life

Introduction

Edible coatings are thin layers of edible material applied to the surface of a product as a natural protective waxy coating or as a replacement for it. These coatings create a barrier to moisture, oxygen, and solute movement in the food. They are applied directly to the food surface through dipping, spraying, or brushing. Edible coatings are used to create a modified atmosphere and to reduce weight loss throughout transport and storage (Ibrahim *et al.,* 2019). The barrier properties of gas exchange in films and coatings have recently garnered significant interest. Extracts or essential oils from plant-based sources have been used, but they require extensive and expensive processing after obtaining the raw extract. Since this approach protects fresh produce from external and internal injuries, provides safety, increases shelf life, and maintains quality, it is extensively utilized in food industries (Kaur *et al.,* 2024).

Aloe vera is currently reported to contain as many as 75 nutrients and 200 active compounds including sugar, anthraquinones, saponins, vitamins, enzymes, minerals, lignin, salicylic acid and amino acids. Chemical constituents are divided into two main classes active constituents of the Aloe vera plant extracts are chromone and anthraquinone and its glycoside derivatives, alongside others such as phenylpyrone derivatives, flavonoids, phenylpropanoids, coumarins, phytosterols, naphthalene analogs, lipids, and vitamins (Jawadul *et al.,*2014). AV leaves have broadly three parts; (i) the rind, (ii) the yellow sap (Aloe latex) and (iii) the internal transparent mucilaginous jelly, called *Aloe vera* gel (AVG). AVG's average composition consists of water (96 %) and dry matter (4 %), which contains organic acids (22.8 %), dietary fiber (18.8 %), polysaccharides (8.8 %), protein (4.7 %), lipids (2.7 %), and ashes (16.0 %) (w/w) (Zhang *et al.,*2018). The composition of AVG is valuable in various areas, including pharmacy, skincare, and food preservation. There are several scientific papers

reviewing the process of obtaining AVG from the aloe plant and the uses of AVG in medical applications. Edible coatings are usually applied by dipping the foods, spraying, or brushing.

Antimicrobial Activity of *Aloe Vera* Gel

Aloe vera plant extracts have antimicrobial characteristics that kill microorganisms (including bacteria (antibacterial activity), fungi (antifungal activity), and viruses (antiviral activity)) or stop their growth. *Aloe vera* gel inhibited the growth of both gram-positive and gram-negative bacteria. Aloe gel is composed of a wide range of constituents which are mainly responsible for this antimicrobial activity against various microorganisms. Anthraquinones presented antimicrobial activity against *Staphylococcus aureus* strains and *Escherichia coli*, through inhibition of solute transport in membranes (Lone *et al.,*2009). *Aloe vera* gel also showed good antibacterial activity against some food borne pathogenic microorganisms such as *Bacillus cereus, Salmonella typhimurium*, *Escherichia coli*, *Klebsiella pneumonia,* etc.

Aloe vera gel can also be an alternative to synthetic preservatives. Leader Daniel Valero and his team at the University of Miguel Hernandez in Alicante, Spain, discovered that Aloe vera gel is edible, colourless, odourless, and does not alter the taste of fruits and vegetables when applied to them. Furthermore, it does not pose any risk to human health. It holds the potential to preserve fruits effectively due to its anti-microbial action, which is described in the beginning (Jawadul *et al.,*2014).

Aloe vera gel impact

Impact on weight loss and firmness

AVG can reduce water loss from many commodities by creating a physical barrier around the fruit. Polysaccharides are considered to be good non-fatty coatings for preventing water loss, and AVG is rich in polysaccharides, which ordinarily provide homogenous edible coatings that are colorless. They have an oily-free appearance and a minor caloric content which is highly effective as a barrier against moisture loss without incorporation of lipids (Iolanda *et al.,*2020). This reduction of weight can be enhanced by adding other components to the AVG coating. For instance, carnauba wax was used at 0.1 % to increase the water barrier properties of the film, as the hydrophobic characteristics of this lipidic component act along with the polysaccharides of the AVG (Perez *et al.,*2016).

The rate and extent of firmness loss during storage are the main factors determining fruit quality and postharvest shelf life. Fruit softening considerably occurs as a result of degradation of the middle lamella of the cell wall. *Aloe vera* gel has been proven to maintain the texture of fruit efficiently.

AVG, which can preserve moisture in the product, also contributes to delaying the loss of firmness. The intracellular water in fruits and vegetables helps maintain their natural turgor pressure. Firmness preservation is due to the barrier properties against O_2, which slows down the respiration rate of the product, thereby reducing the metabolic activity and ripening process. *A. vera* gel shows an effect on the reduction of *â*-galactosidase, polygalacturonase, and pectin methyl-esterase activities attributed to a slow-down on the ripening processes and a decreased stress of the plant.

Impact on colour changes

To retard colour changes in fruits and vegetables, AVG was applied to whole and fresh-cut pieces. *Aloe vera* gel treatment delayed the loss of green colour on the fruit skin of apples stored at 2°C for 6 months. The skin colour of table grapes showed lower increases in Aloe treated than in control (untreated) fruits. Table grapes are rich in anthocyanin compounds, which account for their red

colour. The ripening process of table grapes is linked to the anthocyanin content. After cold storage (1°C, 95% RH), the control fruits showed a redder and darker colour compared to the Aloe-treated ones. This indicated an overripe fruit appearance, which is considered to be harmful to colour quality The modified atmosphere created by the *Aloe vera* gel coating material retarded the ethylene production rate, therefore, delaying ripening, chlorophyll breakdown, anthocyanin accumulation and carotenoid synthesis thus ultimately delaying colour change of fruits.

Impact of AVG coatings on respiration

It is known that environmental temperature affects fruit respiration, and fruit respiration, in turn, affects fruit temperature. When the temperature around the fruit rises, respiration increases which leads to the increase of the temperature inside the fruit. The lower the respiration rate during storage, the higher the shelf life of fruits and vice versa. In the case of Aloe coated table grapes (1°C, 95% RH+ 4 days at 20°C, 90% RH), a controlled respiration rate was observed than the uncoated fruits (Tripati, *et al.,* 2004). The application of a surface coating has been shown to improve the resistance of fruit skin to gas diffusion and the creation of a modified internal atmosphere. The reduction of respiration rate in *Aloe vera* gel coated fruit may be ascribed to the hygroscopic properties that enable the formation of a barrier to diffusion of gasses and water vapor between fruit and the environment.

Conclusion

Aloe vera gel coatings provide an effective and safe alternative to postharvest chemical treatments. The effects of aloe vera gel coatings on enzyme actions such as catalase (CAT), superoxide dismutase (SOD), peroxidase (POD), and PPO, are of great importance for understanding the preservative mechanisms. The biological effects and the mechanisms of action responsible for their effects have been extensively studied and reviewed over the last few decades, however the mechanisms are still unclear. Further research on the compounds responsible for antimicrobial activity is of paramount importance and will broaden the research field of *Aloe vera*.

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CULTIVATING A SUSTAINABLE FUTURE : ORGANIC FARMING IN INDIA

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Organic farming in India is gaining momentum as a viable alternative to conventional farming methods. With the increasing awareness of the long-term drawbacks of chemical-based farming, farmers are turning to organic practices to ensure a sustainable future. Organic farming promotes the use of natural resources, conserves biodiversity, and enhances soil health.

Benefits for Farmers:

- Higher profit margins due to premium prices for organic produce
- Improved soil fertility and reduced soil erosion
- Increased crop resilience to pests and diseases
- Enhanced biodiversity and ecosystem services

Conventional Farming: Immediate Benefits, Long-term Drawbacks
Conventional farming methods, relying heavily on chemical fertilizers and pesticides, have been widely adopted in India. While they offer immediate benefits like increased yields and reduced crop losses, they have severe long-term consequences:

- Soil degradation and reduced fertility
- Water pollution and depletion
- Loss of biodiversity and ecosystem disruption
- Negative impacts on human health and environment

In contrast, organic farming offers a holistic approach to agriculture, prioritizing soil health, biodiversity, and ecosystem balance.

Success Stories and the Way Forward

Organic farming initiatives in India have shown promising results:

- Sikkim's transition to fully organic farming
- Andhra Pradesh's Zero Budget Natural Farming initiative
- Kerala's organic farming initiatives for spices and coffee

To further promote organic farming, the Indian government has launched schemes like the National Programme for Organic Production and the Paramparagat Krishi Vikas Yojana.

Conclusion

Organic farming in India offers a beacon of hope for sustainable agriculture. By adopting organic practices, farmers can ensure a healthier environment, improved livelihoods, and a secure future. As the country moves forward, it's essential to prioritize organic farming and create a supportive ecosystem for farmers to thrive.

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AMPHIBIANS: THREATS AND CONSERVATION MEASURES

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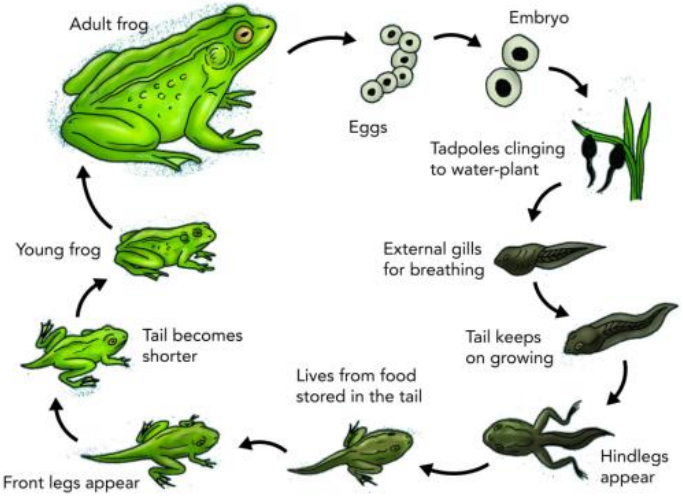
Introduction

Amphibians comprising of frogs, toads and caecilians are important vertebrates of terrestrial and aquatic ecosystems (West, 2018). They play significant role in various ecosystem functions such as predators of invertebrates and as prey of large vertebrates. Further, due to their diverse habitat use they are reliable indicators of ecosystem and landscape health. These are multicellular vertebrates that live both on land and water. They are the first cold-blooded animals to have appeared on land.

Characteristics of Class Amphibia

The characteristics of the organisms present in class amphibia are as follows:

- These can live both on land and in water.
- They are ectothermic animals, found in a warm environment.
- Their body is divided into head and trunk. The tail may or may not be present.
- The skin is smooth and rough, but with glands that make it moist.
- They have no paired fins. Unpaired fins might be present.
- They have two pairs of limbs for locomotion.
- They respire through the lungs and skin. Gills might be present externally in some adults.
- The heart is three chambered.
- The kidneys are mesonephric. The excretory material includes ammonia and urea.
- They possess ten pairs of cranial nerves.
- The lateral line is present during their development.
- The sexes are separate and fertilization is usually external. However, in salamanders, the fertilization is internal.
- Development is indirect with metamorphosis.
- Breeding occurs in water. The copulatory organs are absent in males.



Classification

The Amphibians are divided into three orders viz. Apoda (Gymnophiona or Caecilia), Urodela (Caudata) and Anura (Salientia). Globally there are 5,966 species of Anurans (frog or toad), 619 species of Caudata (Salamandrids) and 186 species of Gymnophiona (caecilian) totalling to 6,771 species (Frost, 2011). In India there are 305 species in 11 families of Anurans, one species in 1 family of Salamander and 36 species in 2 families of Gymnophiona totalling to 342 species

11 families of Anurans are Bufonidae, Dicroglossidae, Micrixalidae, Microhylidae, Nasikabatrachidae, Nyctibatrachidae, Ranidae, Ranixalidae, Rhacophoridae, Sooglossidae and Petrapedatidae. 2 families of Gymophoiona are Caeciliidae and Ichthyophiidae. 1 family of salamander is Salamandridae.

Gymnophiona (caecilian)

Anurans (frog or toad)

Caudata (salamandrids)

Anura (Salientia)

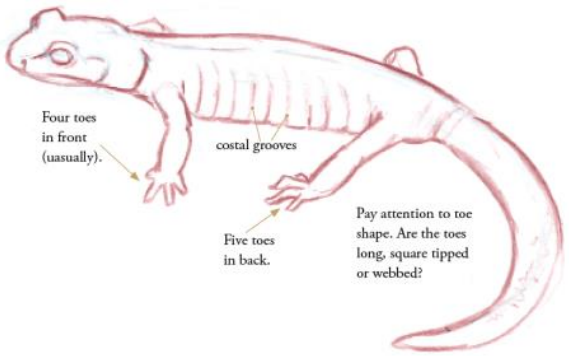
- They have four limbs.
- The front limbs are elongated and modified to jump.
- The head and trunk are fused together.
- The tail is present only in the larval stage and is lost in the adults.
- Fertilization is external and the eggs are laid in water. Eg., frogs and toads.

Apoda (Gymnophiona or Caecilia)

- Apoda means “without legs”. These are limbless organisms with scales on their body.
- They are also known as “blind-worms” because their eyes are covered by skin or bone.
- The tentacles on their head are the chemosensory organs that help them to detect the underground prey.
- They possess venom glands.
- They secrete mucus to reduce water loss. Eg., Caecilians

Urodela (Caudata)

- These are the organisms with a tail.
- The body is elongated with four equally sized limbs.
- The skin is smooth with poison glands.
- Fertilization is internal.
- They feed on insects and worms.
- They are found under leaf litter, in the soil, or in water.
- In the southern US, they reproduce primarily in winters.
- Very little differences between male and female.
- Spermatophores are utilized for internal fertilization.
- They possess hidden gills. Eg., Salamanders



1. Anurans

a. Family - Bufonidae

***Ghatophryne ornata* - Ornate toad, Malabar torrent toad or Black torrent toad**

Scientific classification:

Kingdom - Animalia
Phylum - Chordata
Class - Amphibia
Order - Anura
Family - Bufonidae

Description: A medium sized torrent toad. Dorsum black with grayish spots and patches on the head. Ventral surface black with bright yellowish spots. Head without any bony ridges, skin finely tuberculated.

Habitat: Toad lives in crevices among small rocks to large boulders in streams. Observed to be both active during day and night. It is presumably restricted to tropical evergreen forest. Its breeding is not known, but it presumably breeds by larval development in streams.

Distribution: Karnataka and Kerala parts of Western Ghats.

Abundance: Endemic to Western ghats. Nilgiris hills
Threat: Deforestation (mainly for the cultivation of coffee) in Coorg area and surroundings.

Conservation: IUCN – Endangered. Conservation action - Currently not known with certainty from any protected areas, and strengthened and expanded protection of the remaining forest habitat in this region of the Western Ghats is necessary.

b. Family - Dicroglossidae
***Euphlyctis aloysii* - Aloys skitter frog**

Scientific classification
Kingdom - Animalia
Phylum - Chordata
Class - Amphibia
Order - Anura
Family - Dicroglossidae

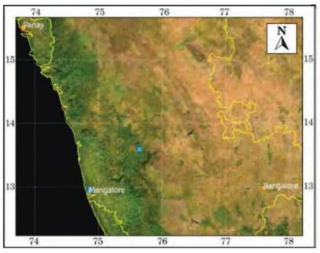
Description: A medium sized frog, dorsum with brown indistinct black spots, limbs marbled with carmine colour.

Habitat: Stagnant water bodies, ponds, tanks in deciduous forest, plantation and human settlements.

Distribution: Kerala and Tamil Nadu part of the Western Ghats.

Abundance: Endemic to Western Ghats

Threat: The habitat of this frog is currently under threat due to extensive land filling activities.
Conservation: IUCN – Data Deficient



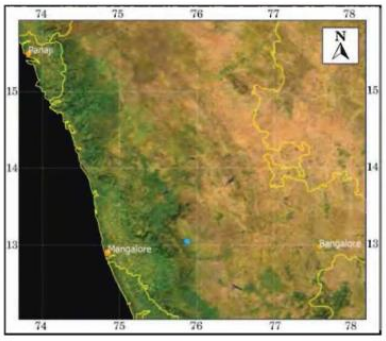
c. Family – Micrlxalidae
***Micrixalus elegans* - Elegant dancing frog**
Scientific classification
Kingdom - Animalia
Phylum - Chordata
Class - Amphibia
Order - Anura
Family - Micrlxalidae

Description: A small sized torrent frog, dorsum crimson, ventrum yellowish colour. Dorsal and ventral surface smooth. lateral region up to the posterior border of the eyes black. Upper jaw whitish, lower jaw with a number of black spots.

Distribution: Karnataka part of the Western Ghats.
Abundance: Occurrence is states along Western Ghats

Threat: Habitat degradation, loss or disturbance due to specific microhabitat requirements; clearance for agricultural use (including coffee cultivation). Unregulated pesticide usage. Disturbance from ecotourists and wildlife photographers in important habitats. Threatened due to river linking projects and water management in general such as pollution, water diversion and potentially bunds or check dams (small temporary dams) which is prevalent across the Western Ghats landscape.

Conservation: IUCN – Data Deficient



d. Family - Microhylidae

***Microhyla sholigari* - Rice frogs or Narrow-mouthed frogs**

Scientific classification

Kingdom - Animalia
Phylum - Chordata
Class - Amphibia
Order - Anura
Family - Microhylidae

Description: A small sized microhylid frog. A light brown mid dorsal marking starting between eyes widens at mid body, narrow on abdomen.

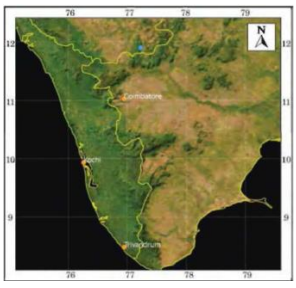
Habitat: Terrestrial species and common in and around human settlements, open areas in forests, and around ponds. They typically inhabit areas with dense grass clumps. They breed in shallow water bodies and possibly in slow flowing streams in forested areas (Welsh Jr *et al.*, 1998).

Distribution: Karnataka part of the Western Ghats.

Abundance: Widespread area of south India.

Threat: Threatened by habitat loss. At present the habitat loss by urbanization and past by agricultural expansion and wood extraction.

Conservation: IUCN - Endangered



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AMRA (INDIAN HOG PLUM: *Spondias mombin*): AN UPDATED TREATISE

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ABSTRACT

Amra (*Spondias mombin*), sometimes referred to as Spanish plum, yellow mombin, or Indian hog plum. This tropical fruit tree, which is a member of the Anacardiaceae family, is native to the Americas, including parts of the Caribbean, Central America, and northern South America. It is widely grown in tropical regions, including India, as well as in subtropical areas that are suitable for it. It needs well-drained, fertile soils as well as a climate that consistently provides warmth and moisture. The fruit of this tree is prized because it can be eaten raw, added to drinks, or processed into pickles, jams, jellies, and traditional medicines. The fruit's high nutritional content includes vital vitamins, minerals, and bioactive substances that boost immune system function, digestive system health, bone health, and antioxidant capabilities, among other important health advantages. Amra enhances soil health through nutrient cycling and erosion management, promotes biodiversity by giving food and habitat to a variety of species, and supports agroforestry and sustainable agriculture. Its vast root system helps to mitigate the effects of climate change by managing water and sequestering carbon. The tree is an important species for ecological and commercial reasons due to its durability in tropical temperatures and capacity to adapt to many types of soil. This article emphasizes the significance of Amra in terms of nutrition, medicine, and the environment, highlighting its potential to improve health and sustainability in tropical areas.

Keywords: Amra, *Spondias mombin,* Indian Hog Plum, Bioactive, Antioxidant, Sustainable

Introduction:

A deciduous tree is the Amra. The word "*mombin*" is Taino in origin, signifying the tree's indigenous origins in the Caribbean, while the genus name "*Spondias*" comes from the Greek word for a particular kind of plum. It has a maximum height of 20 meters (66 feet). The complex, pinnate leaves have nine to twenty-five leaflets each. The tree bears clusters of tiny, greenish-yellow blooms. The fruits are 3-5 cm long, ovoid to ellipsoid drupes with a fibrous, juicy, acidic pulp behind a thin, yellow skin. There is a big, hard seed inside.

Fruit Climate Conditions

1. Temperature: Tropical and subtropical regions are ideal for Amra growth. The ideal temperature range is 68°F to 86°F, or 20°C to 30°C. While it can withstand lows of 10°C (50°F), it is vulnerable to frost.

2. Rainfall: The tree needs between 1,000 and 2,500 mm (40 and 100 inches) of evenly spaced annual precipitation. Even though it likes steady rainfall, it can withstand brief dry spells.

3. Humidity: Tropical areas often have high humidity levels, which are favourable for growth. Extended dry spells with low humidity can call for more watering.

4. Sunlight: Amra grows best in full sun, which encourages rapid growth and prolific fruit production. It can also withstand some shade, however less fruit may come from it.

5. Wind: Avoiding high winds is a good idea because they can physically harm trees and lower their fruit production.

Soil Conditions

1. Soil Type: Although it can tolerate a variety of soil types, including sandy, loamy, and clay soils, Amra grows best in well-drained soils. The tree is more attracted to rich, organically rich soils.

2. pH of the soil: The ideal pH range for soil is between 5.5 and 7.5, which includes slightly acidic to neutral situations.

3. Drainage: To avoid waterlogging, which can result in root rot and other illnesses, adequate drainage is crucial. Mounds or raised beds can be utilized to increase drainage in soils that don't drain well.

4. Soil Fertility: Increase soil fertility by adding organic compost or well-rotted manure on a regular basis. Nutrient balance-nitrogen, phosphorus, and potassium supports fruit production and healthy growth.

Cultural Practices

- **Watering:** While mature trees can withstand dry spells, younger plants need constant irrigation.
- **Mulching:** To retain soil moisture and prevent weed growth, use organic mulch around the base.
- **Fertilization:** During the growing season, apply balanced fertilizers (NPK 10:10:10). In poor soils, more micronutrients can be required.
- **Pruning:** Consistent pruning helps to form the tree, get rid of unhealthy or dead branches, and encourage strong growth.

Control of Diseases and Pests in Amra

Common Diseases

1. Anthracnose (*Colletotrichum gloeosporioides*)

Symptoms: Fruit rot, twig dieback and leaf spots.

Management: Trim and remove any diseased plant material. Use fungicides in the early stages of infection, such as those based on copper compounds. To lower the humidity around the trees, make sure there is enough space between them and airflow.

2. Powdery Mildew (*Oidium spp*.)

Symptoms: Fungal growth on leaves, stems, and fruits that is white and powdery. **Control:** Use fungicides with a sulphur basis. Clear and dispose of diseased plant detritus. Proper pruning will increase air circulation.

3. **Root Rot (*Phytophthora spp*.)**
   Symptoms: Wilting, leaf yellowing, and root deterioration are the symptoms.
   Control: Make sure there is adequate drainage to prevent standing water. Apply fungicides to the soil, such as metalaxyl. Plant in soils that drain well, and don't water too much.

Common Pests

1. **Fruit Flies (*Anastrepha spp*. and *Ceratitis spp*.)**
   Symptoms: Fruit rots and falls off too soon due to maggots inside it.
   Control: Employ attractant-baited traps, such as protein hydrolysate. Gather and dispose of fallen and diseased fruit. Use a cover spray of pesticides like as malathion or spinosad.
2. **Insect Scales (*Coccidae*)**
   Symptoms: Yellowing and wilting of leaves and stems due to the presence of tiny, immobile insects.
   Control: Use insecticidal soaps or horticultural oils. Introduce predators from nature, such as lady bugs. Examine often, and remove scales by hand if you can.
3. **Aphids (*Aphidoidea*)**
   Symptoms: Curled and distorted leaves, emission of honeydew that causes sooty mold.
   Control: Apply insecticidal soaps or neem oil. Encourage lacewings and ladybugs, two examples of natural predators. If infestations are modest, remove aphids by hand on a regular basis.

Strategies for Integrated Pest Management (IPM)

1. **Cultural Practices:** To enhance air circulation, prune regularly and space appropriately. Debris and portions of diseased plants removed and destroyed. Reduce pest build-up by using intercropping and crop rotation.
2. **Biological Control:** Utilizing parasitoids and natural predators to manage pest populations. Beneficial nematodes are introduced to reduce pests that live in the soil.
3. **Chemical Control:** When required, use targeted fungicides and insecticides. To reduce your influence on the environment, use the application rates and timing that are advised.
4. **Monitoring and Early Detection:** Consistently check trees for indications of illness and pests. Use of sticky traps and pheromone traps to identify pests early.

Harvesting and Yield

- **Harvesting Period:** When the fruits become yellow, around six months after they flower, they are usually harvested.
- **Yield:** A well-established tree's yearly fruit yield ranges from 50 to 150 kg, contingent upon its upkeep and surrounding circumstances.

Post-Harvest Handling

- **Storage:** Fruits should be eaten or processed shortly after they are harvested since they have a limited shelf life.
- **Processing:** This method can be used to create drinks, juices, jellies, and jams.

Advantages for the Environment

1. **Biodiversity Support:** Providing food and habitat for a range of creatures, such as birds, insects, and small mammals, is made possible by Indian hog plum trees. While birds and other animals

eat the fruits, pollinators like bees and butterflies are drawn to the blossoms. In the areas where it grows, Amra supports a variety of species, which helps to preserve and improve biodiversity.

2. Improving Soil Health:

Nutrient Cycling: The organic matter and leaf litter of the tree help to cycle nutrients, which enriches the soil with vital nutrients. Other plant growth is supported by this process, which also increases soil fertility.

Erosion Control: Amra wide root system aids in stabilizing the soil and halting erosion. This is especially helpful in places where wind or heavy rain can cause soil erosion.

3. Agroforestry and Sustainable Agriculture:

The Benefits of Intercropping: Amra is frequently utilized in agroforestry systems, where it can be grown alongside other crops. This method produces a variety of products, including fruits, lumber, and fodder, while also improving the efficiency of land use.

Shade and Shelter: The tree offers humans, cattle, and crops that can withstand shade, shade and shelter. By reducing heat stress on plants and animals, this can raise output levels all around.

4. Carbon Sequestration

Reducing Climate Change: During photosynthesis, Indian Hog Plum, like other trees, takes up carbon dioxide from the environment and stores it in its biomass. This procedure lowers the atmospheric quantities of greenhouse gases, which helps to lessen the effects of climate change.

5. Water Management:

Improving Water Retention: Indian Hog Plum trees help improve soil water retention, which increases the amount of water available to other plants. This is particularly crucial in regions where rainfall patterns are erratic.

Reducing Runoff: The roots and canopy structure of the tree aid in lowering surface runoff, which improves water infiltration into the soil and lowers the likelihood of flooding.

Uses

- **Culinary:** Fruit is eaten raw or transformed into jams, jellies, and juices. Its flavour is sour.
- **Conventional Medicine:** Several tree elements, such as the fruit, leaves, and bark, are utilized in conventional medicine with the aim of treating infections and digestive problems.
- **Wood:** Wood is utilized in building and furniture manufacturing. The tree is prized for its shade and aesthetic qualities as well.

Nutritional Composition (per 100 grams of edible portion)

- **Energy:** 68 kcal
- **Carbohydrates:** 17.9 g
- **Proteins:** 0.5 g
- **Fat:** 0.2 g
- **Fiber:** 0.8 g
- **Vitamin C (Ascorbic Acid):** 45 mg
- **Vitamin A:** 18 IU
- **Calcium:** 15 mg
- **Phosphorus:** 22 mg

- **Iron:** 1.2 mg
- **Potassium:** 190 mg
- **Magnesium:** 10 mg

Bioactive Substances

The fruit's antioxidant, antibacterial, and anti-inflammatory qualities are attributed to a variety of bioactive substances, including flavonoids, phenolic compounds, tannins, and saponins.

Advantages for Health

1. **Antioxidant Activity:** The high vitamin C content and phenolic compounds present aid in the fight against free radicals and oxidative stress.
2. **Immune Stimulating:** The fruit's vitamin C concentration fortifies immunity.
3. **Digestive Health:** The fibre helps with digestion and keeps you from being constipated.
4. **Bone Health:** To keep strong bones, phosphate and calcium are necessary.
5. **Prevention of Anaemia:** Iron content promotes the production of red blood cells and guards against anaemia.

Conclusion

The Indian Hog Plum tree is a useful and adaptable tropical tree that provides dietary, health, and financial advantages. It is a viable option for growing in tropical and subtropical areas due to its tolerance to diverse climatic conditions and adaptability to different types of soil. The fruit's health advantages are partly attributed to its high content of bioactive chemicals and critical nutrients.

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BASIC KNOWLEDGE FOR LAC CULTIVATION (*Kerria lacca*)

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History: Lac has been used in India from time immemorial for several purposes, from the epic of Mahabharat it has been recorded that Kauravas built a palace of lac for the destruction of Pandavas. We come across references of lac in the Atharvaveda and Mahabharata, so it can be presumed that ancient Hindus were quite familiar with lac and its uses.

Systematic Position: A number of species of lac insects are known, of this Laccifer lacca is by far the most important and produces the bulk of the lac for commerce.

It belongs to— Phylam — Arthropoda, Class — Insecta, Order — Hemiptera, Super-family — Coccidae, Family — Lacciferidae, Genus — Laccifer, Species — Lacca

Host Plants: The insects live as a parasite, feeding on the sap of certain trees and shrubs. The important trees on which the lac insects breed and thrive well are –Kusum (*Schleichera trijuga*) Palas (*Butea frondosa*) Ber (*Zizyphus jujuba*) Babul (*Acacia arabica*) Khair (*Acacia catcchu*)Arhar (*Cajanus indicus*).

Before coming to the actual mechanism of lac secretion and its processing, it is advisable for a lac-culturist to have detailed knowledge of lac insect and its life cycle. The adult lac insect shows a marked phenomenon of sexual dimorphism.

Identification of Male insect: It is larger in size and red in colour. The body is typically divided into head, thorax and abdomen. The head bears a pair of antennae and a pair of eyes. Mouth parts are absent so a male adult insect is unable to feed. Thorax bears three pairs of legs. Wings may or may not be found. Abdomen is the largest part of the body bearing a pair of caudal setae and sheath containing penis at the posterior end.

Identification of Female insect: It is smaller in size. Head bears a pair of antennae and a single proboscis. Eyes are absent. Thorax is devoid of wings and legs.

The loss of eyes, wings, and legs are due to the fact that the female larvae after settling down once never move again and thus these parts become useless and ultimately atrophy. Abdomen bears a pair of caudal setae. It is female lac insect which secretes the bulk of lac for commerce.

Fertilization: After attaining the maturity, males emerge out from their cells and walk over the lac incrustations. The male enters the female cell through anal tubular opening and inside female cell it fertilizes the female. After copulation, the male dies. One male is capable of fertilizing several females. Females develop very rapidly after fertilization. They take more sap from plants and exude more resin and wax.

Life Cycle: The females after fertilization are capable of producing eggs. But it has been noticed in case of lac insects that the post fertilization developments start when the eggs are still inside the

ovary. These developing eggs are oviposited into the incubating chambers (formed inside the female cell by the body contraction of females). A female is capable of producing about one thousand eggs (average 200-500). Inside incubating chamber, the eggs hatch into larvae.

The larvae are minute, boat shaped, red coloured and measure little over half millimeter in length. Larva consists of head, thorax and abdomen. Head bears a pair of antennae, a pair of simple eyes and a single proboscis. All three thoracic segments are provided with a pair of walking legs. Thorax also bears two pairs of spiracles for respiration. Abdomen is provided with a pair of caudal setae. These larvae begin to wander in search of suitable centre to fix them. This mass movement of larvae from female cell to the new off-shoots of host plant, is termed as “swarming”.

The emergence of larvae from female cell occurs through anal tubular opening of the cell and this emergence may continue for three weeks. The larvae of lac are very sluggish and feed continuously when once they get fixed with the twig. In the meantime the larvae start secreting resinous substance around their body through certain glands present in the body. After some-time the larvae gets fully covered by the lac encasement, also known as lac cell. Once they are fully covered, they moult and begin to feed actively. The cell produced by male and female differ in shape, and can be easily distinguished sometimes later. Male cells are elongated and cigar shaped. There is a pair of branchial pores in the anterior side and a single large circular opening covered by the flap in the posterior side. It is through the posterior circular opening that the matured male lac insect emerges out of its cell.

Female cell is oval, having a pair of small branchial pores in anterior side and a single round anal tubular opening in posterior side. Through the anal tubular opening are protruding waxy white filaments, secreted by the glands in the insects body, which is an indication that the insect inside the cell is alive and is in healthy condition. These filaments also prevent the blocking of the pore during excess secretion of lac. Larvae moult in their respective cells. It is the second stage larva which undergoes pseudopupation for a brief time, whereby it changes into adult stage. Now the male emerges out from its cell, moves on lac incrustation and enters the female cell for fertilization. In this way the life cycle is completed.

Lac Secretion: Lac is a resinous substance secreted by certain glands present in the abdomen of the lac insects. The secretion of lac begins immediately after the larval settlement on the new and tender shoots. This secretion appears first as a shining layer which soon gets hardened after coming in contact with air.

This makes a coating around the insect and the twig on which it is residing. As the secretion continues the coating around one insect meet and fuses completely with the coating of another insect. In this way a continuous or semi-continuous incrustation of lac is formed on the tender shoots.

Cultivation of Lac: Cultivation of lac involves proper care of host plants, regular pruning of host plant, infection or inoculation, crop-reaping, control of insect pests, and forecast of swarming, collection and processing of lac.

The first and perhaps the most important prerequisite for cultivation of lac is the proper care of the host plant. It is the host plants on which lac insects depend for their food, shelter and for completion of their life cycle. There are two ways for the cultivation of host plants. One is that plants should be

allowed to grow in their natural way and the function of lac-culturist is only to protect and care for the proper growth of plants.

Another way is that a particular piece of land is taken for the purpose and systematic plantation of host plant is made there. Regular watch is necessary in this case by providing artificial manures, irrigation facilities, ploughing and protecting the plants from cattle and human beings for which the land should be fenced. The larvae of lac insects are inoculated on host plants only after the host plants have reached a proper height. The lac larvae feed on the cell sap by inserting their proboscis in the tender twigs. The proboscis can only be inserted in the tender young off-shoots. For this before inoculation, prunning of lac host plants is necessary. The branches less than an inch in diametre are selected for pruning. Branches half inch of less in diametre should be cut from the very base of their origin. But the branches more than half inch diametre should be cut at a distance of 1 ½ inch from the base.

Inoculation: The method by which the lac insects are introduced to the new lac host plant is known as inoculation. This may be of two types, namely “Natural infection” and “Artificial infection”. When infection from one plant to other occurs by natural movements of insect, it is called natural infection. This may be due to overcrowding of insect population and nonavailability of tender shoots on a particular tree. Artificial infection takes places through the agencies other than those of nature. Prior to about two weeks of hatching, lac bearing sticks are cut to the size of six inches. They are called“Brood lac”. Brood lacs are then kept for about two weeks in some cool place. When the larvae start emerging from this brood lac, they are supposed to be ready for inoculation. Strings co be used for tieding the brood lac with the host plant may be of different types in longitud infection the brood lac is tied in close contact with host branches. In lateral infection the brood lac is tied across the gaps between two branches. In interlaced method, brood lac is tied among the branches of several new shoots.

Strains of Lac Crop: The lac insects repeat its life cycle twice in a year. There are actually four lac crops since the lac insects behave in two ways either they develop on Kusum plants or devlop on plants other than Kusum. The lac which grows on Non-Kusum plants is called as “Ranjeem lac,” and which grows on Kusum plant is called as “Kusumi lac. Four lac crops have been named after four Hindi months in which they are cut from the tree. They are as follows:

Ranjeeni Crop:

(i) Katki: Lac larvae are inoculated in June-July. Male insect emerges m August-September. Female give rise to swarming larvae in October-November and the crop is reaped in Kartik (October and November).

(ii) Baisakhi: Larvae produced by Katki crop are inoculated in October-November, male insects emerges in February-March, females give rise to swarming larvae m June-July, the crop is reaped in Baisakh (April-May).

Kusumi Crop:

(i) Aghani: Lac larvae are inoculated in June-July, male insect emerges m September, female give rise to swarming larvae in January-February and crop is reaped in Aghan (December-January).

(ii) Jethwi: The larvae produced by Aghani crop is inoculated in the month of January- February, male emerges in March-April, female give rise to swarming larvae in June- July and the crop is reaped in the month of Jethwi (June-July).

Scraping and Processing of lac: Lac cut from the host plant is called as "stick lac". Lac can be scraped from the twigs before or after the emergence of larvae. If it is used for manufacturing before the emergence of larvae, the type of lac produced is called as "Ari lac" and if it is used for manufacturing purpose after swarming of larvae has occurred, the lac is said to be Phunki lac".

The scraping of lac from twig is done by knife, after which they should not be exposed to sun. The scraped lac is grinded in hard stone mills. The unnecessary materials are sorted out In order to remove the finer particles of dirt and colour, this lac is washed repeatedly with cold water.

Now at this stage it is called as "Seed lac" and is exposed to sun for drying. Seed lac is now subjected to the melting process. The melted lac is sieved through cloth and is given the final shape by molding. The final form of lac is called "Shellac". Colour or different chemicals may be mixed during melting process for particular need.

Lac Enemies and Their Control:
A lac enemy imposes a challenge to the lac culturist, as they not only decreases the population of lac insects, but also retard the production and quality of lac. Damage caused to lac insects may be grouped under two heads, (a) damage caused by insects (b) damage caused by animals other than insects. Insect enemies of lac crop may be predators and parasites. The common parasites of lac insect are known as "Chalcid." They are small, winged insects which lay their eggs inside the lac coat either on the body of the lac insect or inside the body of the lac insect. The larva which hatches from these eggs feed upon the lac insects, thereby causing mortality of their host. Damage done by this parasite constitute about 5-10% of the total destruction of the lac crop. Damage done by the predators is of greater intensity (35% of the total destruction). The major predators of lac insects are *Eublemma amabilis* (the white moth) and *Holococera pulverea* (the blackish grey moth). They not only feed on lac insects but also destroy the lac produced by term. Squirrels, monkey, rat, bat, birds (wood peckers), man etc., are the enemies other than insects which destruct the lac crop in different ways. Damage is also done by climatic factors such as excess heat, excess cold, heavy rain, and storm and partly by the faulty cultivation methods.

Control: Damage caused by the above mentioned animals can be reduced to certain extent by the use of the following methods.

Cultural Method: The amount of damage by infection can be reduced to a greater extent by taking care during the culture of lac insects, especially at the time of inoculation. The brood lac showing the minimum enemy attack should be selected for inoculation and should be cut from the host plant very near to the time of emergence of larvae (about one week before the emergence). This will reduce the chances of parasite attack on the emerging larvae at new place (host).

The brood lac used for inoculation should be removed from the new host's branches as soon as the emergence of larvae stops (approx. 3 weeks after inoculation). It reduces the chance of transference of enemies to the new host plant from the brood lac. The infected brood lac not fit for inoculation or the used up brood lac should not be retained for long. The lac should be scrapped at once and t e rest may be crushed or dropped into fire in order to destroy the predators and parasites. The delay m processing also gives chances to the enemy insects to escape into field. So the manufacturers should try to convert stick lac into seed lac as soon as possible. By these cultural methods the future production can be saved from infection to some extent.

Artificial Method: During the crop reaping, it is not always possible for the manufacturers to convert the huge amount of stick lac to seed lac at a time. To avoid the spreading of enemies at this time from stocked stick lac simple artificial method can be used. Bundles of stick lac should be tied with stones and immersed in fenced water (river or ponds) for about a week. This kills all the parasitic and predator insects as they cannot survive in water.

Biological Method: It is an indirect method for killing the parasitic and predator insects. For this purpose, hyper-parasitic insects are used which attacks the parasitic insects of lac and kill them. These hyper-parasitic insects are however, not harmful for lac crop.

Use of Lac: Lac has been used for the welfare of human beings from the great olden days No doubt the development of many synthetic products have made its importance to a little lesser degree, but still it can be included in the list of necessary articles. Lac is used in making toys, bracelets, sealing wax, gramophone records etc. It is also used in making grinding stones, for filling ornaments, for manufacturing of varnishes and paints, for silvering the back of mirror, for encasing cable wires etc., Waste materials produced during the process of stick lac is used for dying purpose. Nail polish is a good example of the by-product of lac.

Composition of Lac: Lac is a mixture of several substances, of which resin is the main constituent. The approximate percentage of different constituents of lac is given below: Resin – 68 to 90%,Dye – 2 to 10%,Wax – 5 to 6%,Mineral matter – 3 to 7%,Albuminous matter – 5 to 10%,Water – 2 to 3%

Present Position of this Industry in India: Lac is produced in a number of countries including India, Thailand, Mayanmar, China, Indonesia, Vietnam and Laos. India and Thailand are the major producers, producing on the average 1700 tonnes of lac annually, followed by China. India alone, accounts for about 70/o of global lac production. Former Bihar is the most important lac producing state of India. The Indian council of Agriculture Research has established Indian Lac Research Institute at Namkum in Ranchi district of Jharkhand.

The average of different states in the total quantity of stick lac produced in this country is given below:
Bihar – 55.5%, Madhya Pradesh – 22%, West Bengal – 10%, Maharashtra – 7.1%, Gujrat – 2.7%, Uttar Pradesh – 1.8%, Assam – 0.6%, Orissa – 0.1%.

Total annual global production of pure lac is estimated to be 20,000 tonnes. The average total production of stick lac in India is about 24,000 tonnes, while the annual average pure lac produced in the country is 11,890 tonnes. About 6000 tonnes of pure lac produced in India is exported to different countries of the world, with an average earning of Rs. 202.38 million in term of foreign exchange. It has been estimated that 3-4 million people mostly tribals are engaged in the cultivation and several thousands in addition are engaged in the trade and manufacture of lac.

Two main competitors of Indian lac are

(i) Thailac, which accounts 50% of the total lac exported

(ii) Synthetic resion, which have replaced lac in certain field. Shellac being a versatile resion, there is immense scope of increasing its utilisation in various fields and there is also scope to modify it to meet particular need.

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BIO-MANIPULATION: A NATURE-BASED SOLUTION FOR EUTROPHIC LAKES

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Abstract
The increasing pressure on natural wetlands due to the intensified agriculture and industrialisation poses a serious ecological risk, eventually turning the natural water bodies eutrophic. The release of excess load of waste into the water bodies leads to eutrophication, thus lowering the productivity per unit area. Reduction of external nutrient loading can be a reliable method, but it may not yield a satisfactory result even after significant reduction in external nutrient loading. Bio-manipulation, a nature based tool, can be effectively used to abet eutrophication by altering the existing food web in the eutrophic lakes**.**

Keywords : Eutrophication, Bio-manipulation, Eco-technology, Planktivorous

Introduction

In the past few decades, the rising global human population, and enhanced welfare, have significantly intensified the pressure on natural marine, terrestrial, and freshwater ecosystems (Millennium Ecosystem Assessment, 2005). Due to the intensified agriculture and industrialization, urban lakes, in particular, experience higher external loading of anthropogenic nutrients, notably phosphorus (P) and nitrogen (N). This influx of nutrients eventually transforms once-pristine lakes into bodies of water characterized by dense algal blooms, unpleasant odours, and mucky bottoms through a process known as eutrophication. The resulted increase in phytoplankton biomass leads to a reduction in water transparency. As the algae die, they sink to the lake bottom, causing an accumulation of dead organic matter in sediment. Hence, eutrophication leads to altered food webs within lake ecosystems, impacting the usability of lake for recreation, fishing, and as sources of drinking water. In its original concept, bio-manipulation encompassed the manipulation of all lake biota and their habitats to improve water quality (Shappiro *et al.,* 1975).

Concept of Bio-manipulation

The term "Bio-manipulation" was initially introduced by Shapiro *et al.,* (1975) to describe a form of 'biological engineering' aimed at manipulating lake food webs to diminish algal biomass. Bio-manipulation is the deliberate modification of ecosystems that involves the addition or removal of species, particularly predators, and can also be broadly defined as the reduction or removal of any undesirable fish, regardless of its impact on zooplankton grazing. The original concept of bio-manipulation is the cascading trophic interactions within aquatic food webs (Polis and Winemiller, 1996). The Bio-manipulation process involves alteration of the food web to encourage zooplankton grazing on algae or reducing algae by introducing planktivorous fish. However, Bio-manipulation is not always a straightforward fish/zooplankton-algae food chain. The Success may be achieved when

fish removal triggers other processes, such as an increase in herbivorous zooplankton like Daphnia which is an effective grazers of phytoplankton. Lakes with persistent high nutrient concentrations, even after substantial reductions in external nutrient loading and elevated algae levels, are considered serious candidates for bio-manipulation. In contemporary times, bio-manipulation is emerging as a popular, cost-effective, and highly efficient technique for lake water quality improvement. For the long-term management of shallow eutrophic lakes, bio-manipulation stands out as a potentially successful tool capable of restoring water clarity (Van de Bund and Van Donk, 2002).

Different ways of Bio-manipulation technique

Fish manipulation

The predominantly used bio-manipulation approach involves the removal of planktivorous and benthivorous fish. Efficient reduction of zooplanktivorous fish biomass typically yields immediate and profound cascading effects in eutrophic lakes. This results in a shift to the dominance of large zooplankton, diminished phytoplankton biomass (including cyanobacteria), increased transparency (Meijer *et al*., 1999), enhanced benthic feeding and herbivorous waterfowl (Allen *et al*., 2007), and a higher proportion of piscivorous fish. Bio-manipulation achieves the desired outcomes only when fish removal is extensive enough (Jeppesen and Sammalkorpi, 2002). Piscivores prey on zooplanktivorous and benthivorous fish, reducing prey fish abundance, lowering fish-induced resuspension, decreasing predation on large zooplankton, and diminishing the translocation of nutrients from sediments to water through feeding and excretion. In warmer locations, where omnivory is common among fishes, stocking pelagic filter-feeding fish has been employed as a bio-manipulation tool (Gonza´lez-Bergonzoni *et al*., 2012). Various carp and tilapia species are introduced to reduce the abundance of noxious filamentous cyanobacteria through direct feeding.

An example of a successfully biomanipualted lake is Huizhou West Lake, China, where fish removal and the introduction of piscivorous fish have led to a substantial improvement in water quality, with the annual mean total nitrogen reduced to less than 1.0 mg L^{-1}, total phosphorus to less than 0.050 mg L^{-1}, and the annual mean concentration of chlorophyll-a dropping to less than 10 mg L^{-1} (Jeppesen *et al*., 2012).

Macrophyte manipulation

In shallow lakes, submerged macrophytes play a crucial role in structuring the ecosystem. Protecting and re-establishing these macrophytes are vital for the long-term recovery of eutrophic lakes. Hence, enclosures designed to protect them from herbivory serve as an alternative or supplementary restoration tool alongside fish manipulation. Aquatic macrophytes are recognized as essential for the sustained success of bio-manipulation management. They stabilize sediment, prevent nutrient re-suspension, and utilize nutrients for their own growth. The macrophytic communities in lakes serve a primary function by providing refuge for zooplankton and establishing zones with low-oxygen levels, which are inhospitable for planktivorous fishes. This creates a barrier that prevents planktivorous fishes from entering the zooplankton refuge. Moreover, an increase in the macrophytic population contributes to the reduction of algal blooms (Hosper and Jagtman, 1990). *Hydrilla verticillata*, *Vallisnaria natans* and *Myriophyllum spicatum* are some examples of macrophytes that can be used in bio-manipulation method.

Enhancement of alternative herbivores

Besides fish and macrophyte manipulation, stocking of aquatic mussels can potentially induce transparent water in lakes following a reduction in nutrient loading (Gulati *et al*., 2008). Mussels

significantly impact shallow lake ecosystems through various mechanisms, including suspension feeding, deposit feeding, grazing, predation, bio-deposition, bioturbation, and shell production. However, their presence in turbid lakes is limited, likely due to predation of their larvae by fish (Gulati *et al*., 2008). The reintroduction of these mussel species could be a valuable tool for restoring the clear water state, but this would likely be ineffective without concurrent fish removal unless large quantities of adult mussels, capable of evading fish predation, are introduced. Mussel stocking not only enhances light penetration by filter feeding but also induces changes in near-bed flows and shear stress due to shell presence. The shells provide colonisable substrate and refuges. One potential candidate is Zebra mussels which through filter feeding can significantly reduce phytoplankton, leading to increased water clarity (Karatayev *et al*., 1997).

Combined Bio-manipulation techniques

Although Bio-manipulation has proven to be a successful tool in restoring eutrophic lakes, the return of lakes to the turbid water conditions within months or years necessitates additional strategies. Hence, combining bio-manipulation with chemical water treatment to precipitate phosphorus and reduce internal phosphorus loading has provided better outcomes (Jeppesen *et al*., 2012). Chemical treatment involves supplying new sorption sites for phosphate on sediment surfaces, known as sediment capping. Phosphate readily adsorbs to substances like calcite ($CaCO_3$), oxidized iron hydroxides, and aluminium hydroxides. The resulting precipitation of phosphorus and a decrease in internal loading through chemical restoration, contribute to improved water clarity. Alternatively, combining bio-manipulation with hypolimnion oxygenation presents another approach. The introduction of oxygen to the hypolimnion enhances conditions for macroinvertebrates and may favour piscivorous fish species. Piscivorous species may benefit from the improved benthic foraging opportunities and can transition from zooplankton consumption to a macroinvertebrate-eating stage before becoming piscivores. Oxygenation of hypolimnion also enhances the redox-sensitive sorption of phosphate to sediment iron, reducing internal phosphorus loading. An alternative involves using electron acceptors such as nitrate as oxidizers. Nitrate can be introduced as a liquid solution by stirring into the upper sediment layer or injecting just above the sediment in the water (Søndergaard *et al*., 2000).

What Happens after a Bio-manipulation?

A successful bio-manipulation yields several "primary effects," notably an increase in zooplankton abundance within 1–2 years. This surge in zooplankton results in diminished algal biomass, leading to improved light conditions and favourable conditions for the establishment of submerged macrophytes. The macrophytes play a crucial role by absorbing nutrients, contributing to a further reduction in algal biomass and initiating a positive spiral of effects (Hansson and Bronmark, 2009). Additionally, the reduction in benthic feeding fish minimizes sediment resuspension, thereby decreasing turbidity, improving light penetration, and reducing damage to macrophytes. Reduced fish feeding at the sediment surface also curtails nutrient transport from sediment to water, diminishing the potential for algal growth. Once established, macrophytes further stabilize the sediment surface, reinforcing the positive spiral. However, another primary effect of fish reduction is decreased food competition among fish. If the bio-manipulation is sufficiently intense, with a high density of piscivorous fish, the recruitment of young fish may not pose a problem (Hansson and Bronmark, 2009). Conversely, insufficient fish removal may lead to young fish, recruited years after bio-manipulation, having access to an abundant food resource due to negligible competition with

larger fish. This potential negative spiral can be mitigated, at least partially, by adding piscivorous fish.

Impact of Bio-manipulation on fisheries and aquaculture

The direct and short-term impacts of the undertaken bio-manipulation measures are notably advantageous to commercial fishermen, who experience tangible benefits as a result of their employment in the designated activities. This not only ensures economic advantages for the fishing industry but also contributes to the provision of high-quality protein to the local population, addressing nutritional needs and fostering food security. Conversely, the indirect and long-term impacts extend beyond the immediate economic gains. The implementation of bio-manipulation contributes to the preservation and enhancement of the lake ecosystem's health and resilience, promoting biodiversity and ecological stability. Furthermore, the pristine beauty of the lake is preserved and possibly improved over time and enhancing the overall quality of the ecosystem. This, in turn, creates a conducive environment for tourism development, attracting visitors and ecological balance of the lake. The confluence of these direct and indirect impacts demonstrates a comprehensive approach that aligns economic interests with environmental sustainability and social well-being (Kaur, 2020).

Effect of Bio-manipulation on Biodiversity

The principle of Bio-manipulation lies in the alteration of the trophic structure of an ecosystem and can stimulate changes in biodiversity. Theoretically, a more balanced fish community after fish manipulation, with reduced top-down control by planktivorous fish, should result in higher diversity at lower trophic levels (zooplankton and phytoplankton) (Jeppesen *et al.,* 2012). Additionally, if submerged macrophytes recolonize and proliferate after bio-manipulation, habitat complexity in the lake littoral will increase, which is expected to create more diverse microhabitats, and foster an increase in overall biodiversity. The removal of fish is anticipated to enhance the biodiversity of plankton by promoting a shift toward a more diverse fish assemblage and reducing nutrient levels (Jeppesen *et al*., 2012).

Challenges for bio-manipulation

Although bio-manipulation has proven as a successful tool for abetting the eutrophic lakes in many part of the world, it is applicable exclusively to small, shallow, and closed ecosystems, necessitating complete isolation of the lake system from other water bodies. Prior to introducing new piscivorous fishes, it is imperative to selectively remove existing fish fauna to mitigate the risk of competition for resources such as food, shelter, and breeding grounds. Additionally, the escalating impact of global developmental activities and climate change significantly exacerbates Lake Eutrophication by intensifying external nutrient influx, leading to alterations in the structure of lake ecosystems. Moreover, the long-term effectiveness of bio-manipulation remains limited (Kaur, 2020).

Conclusion

Although the short-term effects of bio-manipulation have proven to be successful, the long-term prospects have been less optimistic. Bio-manipulation technique should be region specific and adopted considering the eutrophication status of the water body. It should carefully balance the reduction of planktivore fish population and the increase in piscivore fish concentration, considering the long-term sustainability of fauna and flora resources (Kaur, 2020). Though repeated measures can sustain the initial positive effects, further research is necessary to optimize the frequency and

extent of such events. Considering the lack of scientific evidence, controlled experiments, large-scale field studies, and modelling are crucial to elucidate the effects of bio-manipulation, especially in warm lakes. In conclusion, implementing a bio-manipulation strategy alongside nutrient reduction can undoubtedly lead to the restoration of a limnetic environment, thereby increasing its multiple uses and restoring its pristine beauty.

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CARBON FARMING: A WAY TO SUSTAINABLE AGRICULTURE

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Abstract
Agriculture and other biological systems are known to rely heavily on carbon as a vital energy resource. Soil organic matter (SOM) contains carbon, which is essential for influencing soil fertility and structure. The primary sources of carbon that are actively cycling in the ecosystem are the oceans, soil organic matter, biomass (usually vegetation), and atmospheric carbon dioxide (CO_2) (Ussiri, 2017). Increased water retention, nutrient retention, and improved soil structure are all facilitated by organic matter. As a result, a decreased demand for chemical fertilizers and healthier soils enable strong plant development. Agriculture may play a substantial role as a carbon sink through techniques that improve soil and biomass carbon sequestration. Sustaining maximum crop yields and preserving the health of the soil requires adequate amounts of soil organic carbon. Increased crop yield and resistance to environmental stressors are often associated with carbon-rich soils due to their superior root development, microbial activity, and greater nutrient availability. As a potential means of reducing climate change, soil sequestration transforms atmospheric CO_2 into stable organic carbon, enhancing soil quality (Minasny *et al*., 2017). Soils with a high carbon content can withstand more intense weather events and climate variability. Because of their increased capacity to retain water and make nutrients available, they are more resilient to temperature swings, droughts, and floods. This helps to maintain steady agricultural output in the face of shifting weather patterns.

Carbon management in agriculture
Intensive agricultural practices, such as excessive tillage, monoculture farming, and overuse of chemical inputs, can deplete soil carbon levels over time. Adopting sustainable practices that promote carbon sequestration and organic matter accumulation is essential to mitigate this loss. Farmers can enhance soil carbon levels through conservation agriculture techniques like reduced tillage, crop rotation, cover cropping, and organic farming. These practices improve soil health and contribute to climate change alleviation measures by keeping carbon in soils. Government policies and financial incentives can encourage the adoption of carbon-smart agricultural practices. Support for research, extension services, and farmer education is critical to promoting sustainable agriculture and enhancing carbon storage in agricultural landscapes.

In recent years, the concept of carbon farming has arisen as a favourable strategy to mitigate climate change and promote sustainable agriculture practices worldwide. Carbon farming refers to various agricultural practices that increase carbon storage in soil and vegetation. These practices are designed to absorb atmosphericCO_2, an essential greenhouse gas, and include methods like agroforestry, cover cropping, and permaculture (Toensmeier, 2016). The effectiveness of carbon farming in sequestering $CO_2$is significant, as it harnesses the natural process of photosynthesis along with soil organic matter enhancement to capture and store carbon (Sharma *et al*., 2021). At its core,

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carbon farming involves agricultural methods aimed at sequestering carbon dioxide from the atmosphere into the soil and biomass, thereby reducing greenhouse gas levels while enhancing soil fertility and productivity. Carbon farming is increasingly seen as a viable solution, offering the dual benefits of mitigating climate change and strengthening agricultural sustainability (Toensmeier, 2016).

The amount of OC in the soil at any given time depends on the long-term balance between the carbon inputs and the loss rate. These rates are controlled by factors including soil attributes (e.g., soil lithology and texture), climatic variables, biotic characteristics (e.g., microbial population and biomass production), and anthropogenic factors (such as land use and management) (Zdruli *et al*., 2017). These factors affect SOC stock by influencing the SOC decomposition rate, SOC absorption and stabilization, altering moisture regime and the vertical redistribution of SOC in the soil profile (Akpa *et al*., 2016).

Carbon farming

It represents a strategic approach aimed at maximising carbon sequestration and employing agricultural practices designed to enhance the absorption of carbon dioxide (CO_2) from the atmosphere while facilitating its retention in both plant biomass and soil organic matter. Biological carbon sequestration involves the process of photosynthesis in plants, where $CO_2$is converted into organic compounds and stored in plant tissues (Farrelly *et al*., 2013).This process requires careful planning, monitoring, and adaptation to local conditions to maximise its effectiveness in mitigating climate change. Carbon farming approaches, such as cover cropping and reduced tillage, promote healthy soil biology and organic matter content, significantly increasing the soil's capacity to capture and store carbon.

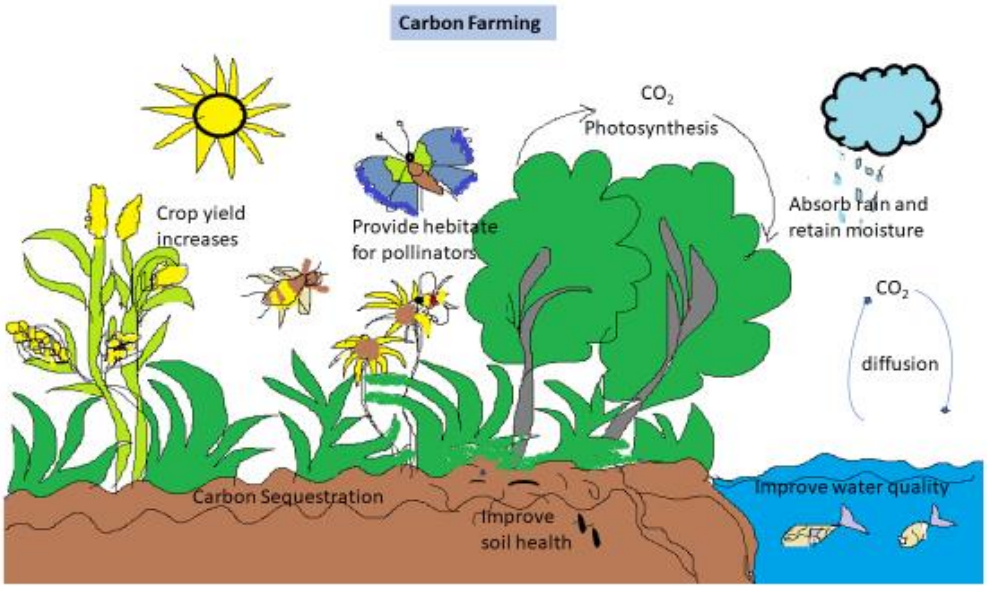

Fig 1: Carbon Farming components

Techniques of Carbon Farming

Carbon farming encompasses a variety of techniques tailored to enhance carbon sequestration within agricultural landscapes. These techniques include:

1. **Agroforestry**: Introducing trees and shrubs into agricultural lands provides additional income streams through timber and fruits and sequesters significant amounts of carbon in woody biomass and soil organic matter. The density of forests constitutes another critical factor affecting the soil carbon content and deforestation substantially influences the flow of rivers and land use patterns (Tan *et al*., 2015).
2. **Cover Cropping**: Planting cover crops during off-seasons helps control soil erosion, enhance soil structure, and improve organic matter content, therefore boosting carbon storage. Enhancing root biomass by selecting crops with deeper root systems contributes significantly to soil carbon sequestration (Kumar *et al*., 2018).
3. **No-Till Farming**: Farmers can preserve soil structure and organic matter by avoiding traditional ploughing methods, thereby reducing carbon emissions from soil disturbance and enhancing carbon sequestration.
4. **Rotational Grazing**: Managing livestock to mimic natural grazing patterns can improve soil health, increase vegetation cover, and sequester carbon in the soil.
5. **Biochar Application**: Utilizing biochar, a stable form of charcoal produced from biomass, can enhance soil fertility, water retention, and carbon storage capacity over the long term. Biochar has been identified as an effective method for long-term carbon storage in soils (Lorenz, 2014).

Significance of Carbon Farming:

- Climate Change Mitigation: Carbon farming is pivotal in the fight against climate change. It sequesters carbon in soil and curbs greenhouse gas emissions.
- Soil Health Enhancement: Carbon farming nurtures healthy soil, bolstering water retention, diminishing erosion, and boosting nutrient availability, resulting in amplified crop yields and agricultural productivity.
- Converting organic waste into compost can be used as a soil amendment to enhance soil structure, fertility, and carbon content.
- Biodiversity Enrichment: Carbon farming fosters biodiversity by fostering intricate ecosystems in agricultural settings, attracting beneficial insects and pollinators that fortify crop health and lessen pesticide dependence.
- Economic Opportunities: Implementing carbon farming practices opens avenues for farmers to tap into carbon credit markets alongside potentially augmented yields from enriched soil, thus diversifying income streams and bolstering financial resilience.

Challenges in Carbon Farming

Carbon farming initiatives require agro-environmental approaches to incentivize farmers to embrace best farm management practices. However, getting farmers involved in such programs is usually challenging, mainly because of the complex scheme design and its implementation or conflicting targets of policy-makers and the farmers (Salas Castelo, 2017).Political fluctuation also substantially influences the approval and performance of such practices (Conant *et al*., 2011).Similarly, uncertainty about environmental influences and lack of understanding of such schemes and policies may also undermine their adoption (Toensmeier, 2016).

Future prospects

- Climate Change and Agriculture: Adaptation strategies can benefit climate-resilient and emission-reducing agricultural practices.

- Viability of Organic Farming in India: Grassroots initiatives and agricultural research in India demonstrate the viability of organic farming for carbon sequestration.
- Regional Suitability for Carbon Farming: Regions like the Indo-Gangetic plains and the Deccan Plateau are well-suited for carbon farming.
- The mountainous terrain of the Himalayan region and coastal areas face challenges like salinisation and limited resources, limiting the adoption of traditional farming practices. Therefore, these areas can be utilised for carbon farming after capacity building.

- Role of Carbon Credit Systems: Carbon credit systems can incentivise farmers by providing additional income through environmental services.

Conclusions

Sustainable agricultural production practices are encouraged by increasing human demands and subsequent environmental effects. The dependence of the farm output on climatic change can be stabilized by using less intensive and judiciously organized farming methods. Carbon farming is also known for reducing GHG emissions and carbon sequestration, which rely primarily on climate requirements, soil characteristics, vegetation, and land-use practices. It extends beyond carbon sequestration, encompassing significant environmental, economic, and social benefits. Challenges such as implementation costs, ecological variability, and the need for robust policy support remain. The future of carbon farming in India appears promising, with technological innovations and policy integration potentially enhancing its effectiveness.

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TECH-TUNED FARMS: CLIMATE SMART MECHANISATION IN AGRICULTURE

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Abstract

This article examines how advanced machinery and technologies are revolutionizing agriculture through climate-smart mechanization. As climate challenges increase, innovations like precision farming, digital agriculture, and automated irrigation are crucial for enhancing sustainability and productivity. Precision farming employs GPS-based systems and real-time controllers to optimize resources and reduce environmental impacts. Next-gen drones aid vertical farming and precision nutrient management, while automated irrigation systems efficiently manage water use. Remote sensing technologies, such as RGB/CIR cameras and multispectral imagery, support precise fertilizer application and crop monitoring. Additionally, agri-bots address labor shortages and boost productivity. Effective policy and financial support are essential for advancing these technologies and fostering sustainable agriculture.

Introduction

Agriculture is increasingly susceptible to the impacts of natural and climatic adversities, which threaten both agricultural productivity and farmers' livelihoods. To address these challenges, the agricultural sector must undergo a significant transformation, enhancing its sustainability and resilience while safeguarding food security. The rapid advancement of technology, expanding urbanization, and modern farming practices are all reshaping the agriculture landscape. Smart farm mechanization technology presents both challenges and opportunities for evolving agriculture into a more intelligent, productive, and sustainable industry that is economically viable and socially equitable. Smart farming employs cutting-edge technologies like precision and digital agriculture to boost the quality and quantity of produce while maximizing resource efficiency. Climate-smart mechanization, a forward-thinking approach, aims to build resilient agricultural systems and value chains to ensure long-term food security amidst climate change. This approach integrates artificial intelligence for precise weather forecasting, pest and disease management, and optimized application of water and nutrients to enhance crop planning and yields. While mechanization itself is not a new concept, adapting it for climate-smart agriculture introduces innovative methods for improving productivity and sustainability. This chapter delves into various mechanization practices and explores advanced machinery used in farm operations—from seedbed preparation to threshing and processing. These technologies not only enhance machinery efficiency but also contribute to

the conservation of crucial resources such as seeds, fertilizers, chemicals, water, and energy, paving the way for sustainable agricultural practices.

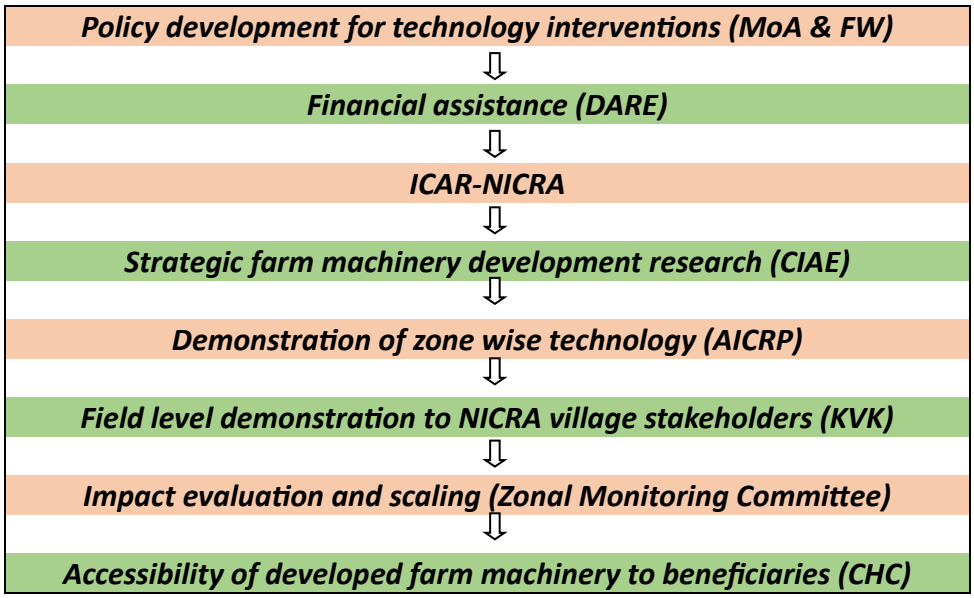

Fig 1: Climate smart mechanisation action plan

Climate-Smart Technology-Based Farm Mechanization

A vast array of farm equipment is included in climate-smart mechanization, which is used for various agricultural tasks like preparing seedbeds, planting and sowing, intercultural operations, irrigation, managing nutrients, protecting plants, harvesting, threshing, and even managing straw in crop post-harvesting.

Mechanization in seedbed preparation:

Seed bed arrangement is the first step toward optimal crop development, which has a big impact on production. Tillage is the initial step in the preparation of the seed bed i.e. the process of mechanically modifying soil to prevent weed growth, prepare seedbeds, and foster a healthy, permeable root environment. Mold board and chisel ploughing decrease organic matter in the soil, add air to the soil, and stimulate biological activity. The conservation tillage (CT) technique reduces the intensity of tillage and retains or mulches crop residue, protecting natural resources like soil, water, and energy. Preservation Minimal soil disturbance is required for crop planting, growth, and harvesting when using tillage. When planting, it leaves crop residue on at least 30% of the soil's surface. CT techniques include ridge, zero, mulch and strip-till. Soil organic carbon (SOC) sequestration is higher with conservation tillage (No-tillage) than with conventional tillage. In rice-wheat cropping systems, zero tillage reduced CO_2 emissions by 0.25 mg by saving one million liters of irrigation water and 98 liters of diesel. In combination tillage, the quantity and length of field activities are decreased by simultaneously manipulating the soil with two or more distinct tillage implements. Soil compaction, labor expenditures, and gasoline costs decrease with fewer visits.

Mechanization in sowing and planting:

An important phase of development in the production of agriculture is sowing and planting. A specific crop cannot be manually sown or transplanted within a given time frame due to the labor shortage and human constraints. If done manually, this could cause climatic change and delay the operation. Mechanization can lead to accurate and timely work, cost-effectiveness, efficient use of

resources and inputs, and conservation of resources like water and soil. Furrow irrigated raised bed planters, tractor-mounted raised bed planters, turbo happy seeders, semi-automatic vegetable planters, tractor-operated small seed planters, and other climate-smart farm equipment are some of the significant pieces of equipment utilized during sowing and planting.

Mechanization in weeding operation:

A variety of mechanical weeding instruments, such as tractor-drawn row crop cultivators, animal-drawn weeding tools, push-pull type weeders, marsh weeders, and hand hoes, were employed in crop rows to minimize weeds. The poor effectiveness of these conventional weed management instruments causes weeding to be delayed and expensive. Researchers from wealthy and emerging nations concentrated on mechanization in weeding operations to address these problems. A breakthrough in mechanical weed management in row crops may come from combining cutting-edge technology like sensing and robotic weed control systems, machine vision, and RTK GPS guidance systems with new cropping techniques. This led to a notable decrease in labor-intensive tasks and time spent weeding.

Using an offset rotavators, weeding beneath the plant canopy and around the plant girth becomes simple. This enables us to perform inter cultivation operations more efficiently, resulting in time and drudgery savings. In India, offset rotavators are being introduced which have good field performance but higher operational cost. A tractor-powered rotary weeder is ideal for weeding in larger row crops. There is a 74% reduction in labour costs and a 56% reduction in operating costs.

Mechanization in irrigation system

Water is essential for agricultural development, especially under rainfed conditions. With the ongoing population growth and the expected impacts of climate change *viz.*, changes in precipitation patterns and glacier melting-the water crisis is becoming more severe. Soil moisture management is critical for irrigation but can be challenging to measure and maintain at optimal levels. An automated irrigation system offers an effective solution to this issue. Such a system utilizes soil moisture sensors to monitor soil conditions and automatically activates irrigation when moisture levels fall below the required threshold for healthy plant growth. Once the target moisture level is achieved, the system can be programmed to stop irrigation during specified times in the morning and evening. The system's core is a microcontroller, chosen for its reliability and cost-effectiveness. Automated and mechanized farming systems contribute to reducing water wastage, which is particularly beneficial for small farmers aiming to increase crop yields while conserving water. Key components of an automated irrigation system include a real-time clock, moisture, temperature, and humidity sensors, an irrigation supply system, and a system controller. For example, an automated drip irrigation system can enhance cucumber yields by providing precise amounts of water at the right times. Additionally, the technique of aqua sowing involves planting seeds and simultaneously supplying enough water to ensure germination, regardless of rainfall. This advanced technology is especially useful for dry-land farmers, allowing them to sow seeds effectively during the late monsoon season.

Mechanization in nutrient management:

Effective crop growth management in real time without causing damage is essential for modern crop production. Traditional methods often involve destructive plant sampling and time-consuming, labor-intensive physical and chemical analyses. To address these challenges, climate-smart farming equipment, such as GPS-based Variable Rate Technology (VRT) fertilizer applicators, can be used. These systems, which include a microcontroller and actuator along with a seed and fertilizer drill, operate within a precision map-based framework. Compared to conventional methods, VRT systems

can reduce granular fertilizer variability by up to 15% and save 13-15% of fertilizer. Remote sensing imaging systems offer a range of solutions for fertilization tasks. Among these, RGB/CIR cameras, which combine infrared (CIR) with red, green, and blue light imagery (visible or RGB), are particularly useful for estimating green biomass and nitrogen status using the Normalized Difference Vegetation Index (NDVI). Additionally, various companies provide aerial remote sensing services using multispectral, hyperspectral, or thermal imagery to diagnose nutrient deficiencies in crops such as wheat, rice, cotton, and other horticultural plants.

✚	Promoting precision farming and digital agriculture with R&D and financial support.
✚	Enhancing vertical farming with cutting-edge drones featuring AI and advanced navigation.
✚	Expanding precision and smart agriculture through private sector involvement.
✚	Creating interactive digital platforms for farmers to access tech, expertise, and management tools.
✚	Developing expertise in AI, precision, and digital agriculture technologies.
✚	Using drone data for crop insurance claims and damage assessments.
✚	Advancing agri-bots to reduce labor needs and increase productivity.

Figure 2: Key strategies to promote tech-tuned farms

Mechanization in Harvesting and Threshing

Recent advancements in harvesting and threshing methods aim to enhance their benefits for humans and produce finer straw, which facilitates quicker soil mixing. However, these improvements have led to a minor increase in carbon emissions from harvesting and threshing machinery. Combine harvesting, which integrates the harvesting and threshing processes, consumes less diesel compared to traditional methods where manual or reaper harvesting is followed by separate threshing. In addition to conventional petroleum fuels, renewable fuels such as biofuels made from agricultural waste can be used in agricultural engines. This approach does not require sacrificing productive land and results in lower emissions. Renewable fuels are more efficient than diesel and can contribute to greater climate resilience.

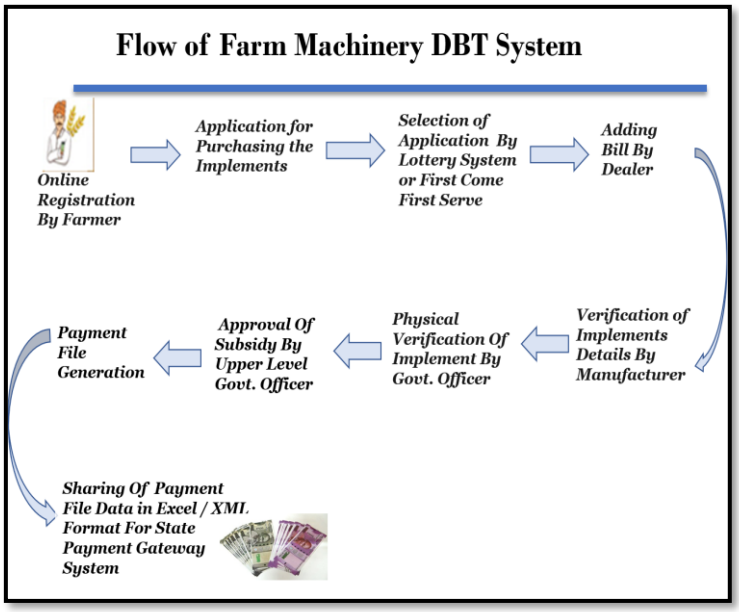

Figure 3: Farm machinery DBT system

Conclusion

Climate-smart mechanization is essential for modernizing agriculture in response to climate change. Equipment like zero till drills, laser land levellers, and controlled traffic systems minimize soil disturbance, reduce greenhouse gas emissions, and enhance carbon storage in the soil. With growing demand from emerging markets, these technologies also help reduce water waste. Automated irrigation systems, supported by sensors and real-time controllers, optimize water use, while remote sensing aids in precise fertilizer application, benefiting both the environment and crop management. Prioritizing crop residue management and providing initial government support for farm machinery development are crucial for effective climate adaptation and farmer adoption.

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THE IMPACT OF CLIMATE CHANGE ON DARJEELING MANDARIN: CONSTRAINTS AND ADAPTATION STRATEGIES

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Abstract
Climate change is an inescapable and urgent concern of our decade, with extensive ramifications that impact horticulture, an essential practice of world food production and economic viability. Global temperatures are escalating, resulting in altered climate patterns and an increased occurrence of catastrophic weather events. The impacts of climate change are not consistent across different locations. Vulnerabilities and adaptive capabilities differ based on geographic location and socio-economic background. Increasing temperatures influence plant growth, blooming, and fruiting of Darjeeling mandarin, thus affecting the production and quality of mandarin. Areas like Darjeeling and surrounding areas with vulnerable ecosystems and scarce resources face increased risk, whereas regions with developed infrastructure and adaptive capacities possess superior methods to mitigate and adapt. Climate change is transforming Darjeeling mandarin cultivation, introducing both difficulties and opportunities. Through the implementation of adaptive techniques and ongoing research initiatives, Darjeeling mandarin cultivation may persist and flourish, resulting in promoting sustainable agriculture and enhancing farmers' income in this region. This study presented a worldwide viewpoint and highlighted adaptation options to mitigate these issues.

Keywords : Climate change, Darjeeling mandarin, constraints, adoption

Introduction

Climate change, primarily caused by the rising levels of greenhouse gases in the atmosphere, has become one of the most urgent global concerns of the 21st century. The Intergovernmental Panel on Climate Change (IPCC) forecasts an upsurge of 2.5–10°F over the next century (Shafqat *et al*., 2021). The ramifications of this occurrence have extensive implications that span several fields, notably agriculture, where horticulture plays a crucial role in worldwide food supply, dietary variety, and economic viability. Horticulture involves the production of many crops, including fruits, vegetables, decorative plants, and medicinal herbs and is directly connected to the environment and climate. The shifting climate provides a significant challenge to horticultural crops, as they depend on certain climatic conditions and any disturbances in climatic conditions affect their growth and yield. Although climate change has varying impacts across the globe, the geographic locations and socio-economic circumstances result in different levels of vulnerability and ability to respond to these difficulties. Horticultural crops are extremely perishable and extremely susceptible to erratic climatic variation, due to which it became more vulnerable than any other farming sector. Mandarin or Darjeeling orange (*Citrus reticulata* Blanco), one of the most important horticultural crops is an exclusive citrus fruit native to the Darjeeling district (Singh *et al*., 2003). This fruit sometimes called "Suntala," is highly valued in the Darjeeling hills for its exquisite fragrance and taste. West Bengal

alone produces 40,000 tons of mandarin which has a share of over 0.79% of India's mandarin production (Sarkar *et al*., 2023). In the past ten years, there has been a significant decrease in the quality and output of mandarins in the Darjeeling region, mostly owing to severe abiotic and biotic stresses. The primary factors contributing to the decline in area and production include the prevalence of diseases such as Citrus gummosis, Citrus Tristeza Virus and Citrus greening, and pests like citrus trunk borers and fruit flies. Other contributing factors include inadequate cultural practices, presence of old and senile orchards, and lack of high-quality planting materials. The climate change also played a significant role in this decline of mandarin cultivation. Regions with vulnerable ecosystems and limited resources are particularly sensitive to climate-induced alterations in horticulture practices. Farmers in the region reported that increased temperatures and events of erratic rainfall affected the yield and quality of Darjeeling mandarin. The present article will explore the diverse impact of climate change on Darjeeling mandarin and strategies for adaptation.

Climate of Darjeeling and Kalimpong area:

Global climate has continuously been changing. Figure 1 shows the rise in global temperature throughout the last 40 years. Besides that, the water scarcity has also increased (Figure 2). Darjeeling region is located in the northern hemisphere of the Earth and the amount of rainfall during the summer season is considerably higher than during the winter season. The average annual temperature recorded in Darjeeling is 16.7 °C. Annually, there is an estimated 3558 mm of precipitation and the altitude of Darjeeling, ranges from 600 to 2000 meters above sea level (https://en.climate-data.org/asia/india/west-bengal/darjeeling-33809/). Kalimpong, which is also located in the northern hemisphere is characterized by gentle and consistently warm weather. The altitude of Kalimpong is 1247 meters from sea level. The average annual temperature recorded in Kalimpong is 17.9 °C and the annual precipitation at this location amounts to around 3053 mm (https://en.climate-data.org/asia/india/west-bengal/kalimpong-33810/). The varied heights of Darjeeling and Kalimpong lead to variations in sunshine exposure, with higher elevations receiving less direct sunlight in comparison to lower areas.

Like the whole world, Darjeeling Hill has experienced a rapid change in climate in the last few years. The average temperature in Darjeeling has risen by 4 °C, which is twice the global average. Additionally, the yearly averages of daily maximum and minimum temperatures in Darjeeling have climbed by far larger margins. Over the same time frame, there has been a 7% drop in relative humidity and an annual reduction of 300 millimetres in rainfall (Basumajumdar, 2016). In 2016, the Darjeeling Himalayas faced acid rain, which occurred as a result of air pollution and caused harm to forests and plantations and the pH value was recorded at 4.2 to 5.0 (Saikawa*et al*., 2019, Kumar *et al*., 2022). All these events had significant effect on the growth, yield and quality of Darjeeling mandarin.

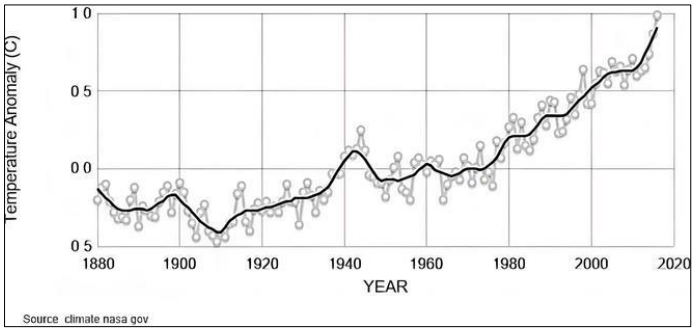

Fig 1: Rise in global surface temperature (Shafqat *et al*., 2021)

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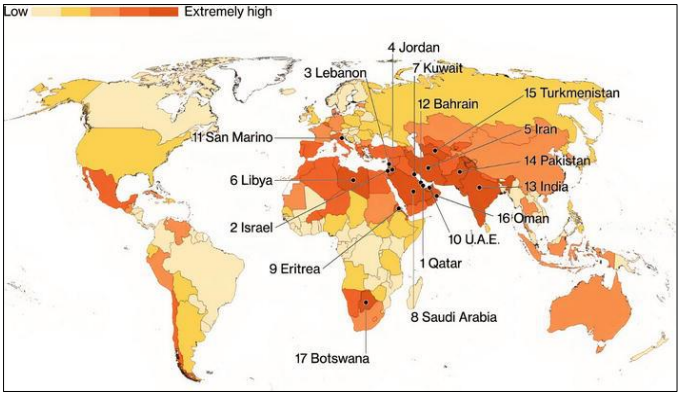

Fig 2: Risk of extremely high-water stress countries (Shafqat *et al*., 2021)

Climate required for Darjeeling mandarin cultivation

Mandarins thrive in frost-free tropical and sub-tropical areas, reaching elevations of up to 1,500 m above sea level. The crop grows in regions with an annual rainfall of 120-160 cm and a temperature range of 10-30º C. The cultivation of Darjeeling mandarin is best suited for medium to extremely deep fine loamy soils or sandy loamy soils with a somewhat heavy sub-soil. These soils should be well-drained and have a pH ranging from 5.5 to 6.5 (Sarkar *et al*., 2023).

Climatic factors for decline in Darjeeling mandarin cultivation

- **Erratic or uneven rainfall**
  Irregular and inconsistent rainfall, have rendered the production of Darjeeling mandarins unsuitable for certain agricultural groups. De (2017) stated that prolonged and intense rainfall might harm during the blooming and fruit-setting stages and promote the growth of mosses, lichens, and fungal diseases (De, 2017).
- **Increased temperature**
  The Darjeeling mandarin thrives in the optimal growing conditions of the Himalayan region, which directly influences its quality. But recently farmers have observed major climatic changes in the Himalayan tract of Kalimpong and Darjeeling, including increased temperature (Sarkar *et al*., 2023). This increased temperature caused sun scorching of fruit and increased the irrigation requirement in its cultivation.
- **Fog and frost**
  Fog significantly reduces the availability of light and hampers the process of photosynthesis, whereas spring frosts pose a particularly detrimental impact on plants. Frost can either damage a plant's reproductive organs or destroy the blossoms. This, in turn, can impact the process of fruit formation and ultimately affect the fruit yield. Frost is considered a significant factor that can have a severe impact on the behaviour and survival of plants and trees (Kumar & Nath, 2013).
- **Shift in season**
  Climate change also causes alterations in precipitation patterns, such as increased occurrences of droughts and more extreme rainfall events. These alterations can potentially disturb the water supply for horticulture crops like mandarin. Drought stress can lead to diminished crop development, decreased production, and, in certain instances, complete crop failure (Wiebe *et al*., 2020). The recent changes in climate patterns, including a shift in seasons, an increase in temperature, and frequent occurrences of unpredictable and

irregular rainfall, have rendered the production of Darjeeling mandarins unsuitable for certain agricultural farmers. Farmers reported about early flowering and harvesting in few locations under changing climatic scenarios.

- **Landslide**
  The Shiwalik Hills, similar to the majority of the Himalayan foothills, possess steep inclines with loose and soft upper layers of soil, resulting in frequent occurrences of landslides during the monsoon season (Mamata 2006). Intense precipitation within a few days result in heavy erosion of soil and landslides in many orchards causing huge economic loss to the farmers.
- **Untimely hailstorm**
  The unexpected hailstorm is a significant environmental or climatic factor that is a crucial part of farmers' decision to leave mandarin cultivation in the Darjeeling Himalayas (Sarkar *et al*., 2021). The farmers reported that untimely hailstorms significantly affecting the flowering and fruit setting of mandarin crops and causing huge economic losses.
- **Drying streams or springs quickly**
  Other climatic disasters, like the drying up of streams or springs, leading to water scarcity are also reasons for the leaving of mandarin cultivation in these areas (Sarkar *et al*., 2021).

Impact of climate change on Darjeeling mandarin Cultivation:

Production decline:

Increased temperature and moisture stress have detrimental effects on the production and quality of oranges. They lead to increased fruit cracking and cessation in oranges, resulting in a drop in overall yield (Muchie & Assefa 2021). In conditions of groundwater scarcity, citrus trees experience stomata closure due to high levels of ABA, leading to a rapid decline in photosynthesis and subsequent losses in overall production as chlorophyll *a* and chlorophyll b are easily damaged due to lack of water (Shafqat *et al*., 2021). Under situations of water scarcity, citrus plants decrease stomatal conductivity and increase photorespiration, resulting in reduced fruit yield, size, and quality (Arbona *et al*., 2005).

Area decline:

The mandarin cultivation area in Darjeeling was 30,000 hectares in the year between 1999-2000. In the year 2007-08, the total area of land dedicated to Darjeeling mandarin cultivation was 1972 hectares. Now, the area has decreased to 1600 hectares (Tarafdar *et al*., 2017). In the Mangmaya area, approximately 90% of the farmers have abandoned mandarin cultivation. Villages like Bongbusty, Icheygaon, Samthar, Suruk, Pabung etc. of Kalimpong also witnessed a significant 70% decrease in mandarin cultivation (Sarkar *et al*., 2023).

Shift in cultivation zone at higher altitude

Farmers from the foothills of the Darjeeling Himalaya region like Samsi, Gorubathan, Suntalabari, Teesta dam and Mungpoo reported that earlier they cultivated Darjeeling mandarin and it was their main livelihood source. But, now under changing climatic scenarios, the yield and quality of mandarin declined. Now, the cultivation of mandarin has shifted towards higher altitudes like the upper sub-Himalayan region of Darjeeling and Sikkim earlier it was not grown.

Shifting towards other agricultural crops

The farmers from the Mungpoo, Mirik and Sittong regions have decreased mandarin cultivation by 80%, 75% and 50% respectively and it has been redirected to other agricultural and non-agricultural

use (Sarkar *et al*., 2023). Since 60 percent of the land used for growing mandarins of the farmers belonging to Dhoja Tea Estate, Malat Raigaon, Munda, DhulreBalason, Sampripani, Avongrove, Dhajey Basti, Orange Villa, and Nagori Farm has been redirected towards various alternative agricultural and non-agricultural enterprises (Sarkar *et al*., 2023). Acharya (2019) reported that more than 50 % of the total mandarin cultivation area has already been transformed into different vegetables, crops and large cardamom cultivation. Some of them turned their orchard into homestays for tourism.

Emergence of new pests and diseases

Meena *et al*. (2017) identified insect pest infestation and citrus dieback as the most significant constraint. The occurrence of new pests and illnesses in the higher hill area is linked to climatic change, which was previously unknown to the farmers. Excessive wetness can promote the growth and spread of illnesses in horticulture crops by creating favourable circumstances for the development of pathogens (Chachar *et al*., 2023). This posed a significant danger to the farmers and was regarded as the primary climatic element contributing to the collapse of mandarin cultivation (Meena *et al*., 2017). Recently, the occurrence of black citrus aphids in the Kalimpong region has increased. Increased rainfall and humidity create favourable conditions for the proliferation of diseases caused by Phytophthora sp. This effect is further amplified when combined with prolonged growing seasons (Verma *et al*., 2013).

Quality decline

Higher temperature leads to early maturity and while the extreme rainfall could reduce the sugar content of mandarin during ripening (Dong *et al*., 2024). Elevated temperatures can cause physiological stress on mandarin trees, resulting in diminished fruit development which can lead to the production of smaller, less sugary fruits. Water stress can also impact the trees' capacity to produce superior-quality fruit due to alterations in rainfall patterns and water availability (Shafqat *et al*., 2021). Severe cold and frost can also damage the tree and affect fruit quality.

Unemployment and migration of youth

The North Bengal area harbours a significant population of worker groups. Annually, the region witnesses a significant exodus of young individuals to states like Kerala, Karnataka, and other states. Because of the production decline and losses, many young farmers of mandarin leave agricultural practices and move to other states for other employment opportunities.

Water scarcity for irrigation

Due to the rise in temperature, the mountain springs or streams are getting dried up even before January. As a result, farmers could not irrigate the mandarin orchard using the water of this spring unlike earlier. People from these areas are facing water shortages even for their drinking purposes so irrigation work for their mandarin cultivation is like a lavish thing for them. Verma *et al*., 2013 showed in their study that the prolonged period of drought from November to March causes moisture deficiency in several horticultural crops, leading to the deterioration of the young Khasi mandarin orchard over the whole North East Himalayan Region.

Decreased soil fertility

The dryness of the soil and the rising temperature have an impact on the health of the soil microbial population, which in turn leads to a decrease in the microbial population and ultimately infertility of the soil. The recent trend of heavy rainfall has resulted in the loss of highly fertile soil and reduced land productivity in the region.

Shift in harvesting time

Photoperiodism, rainfall, and temperature impose substantial effects on any crop's yield and quality, as it affects their flowering, fruiting, and ripening time. This eventually changes the traditional harvesting period of the mandarin (Dong *et al*., 2024).

Adaptation and coping strategies

1. **Adoption of climate resilient varieties and cultivars**
   Changsha mandarin, Satsuma mandarin, and Kumquat are cold-hardy varieties of mandarin which can be used in cold harsh climates like in the upper region of Darjeeling Himalaya. Drought tolerant variety like Owari Satsuma mandarin and drought tolerant varieties like Valencia and Hamlin can also be planted in the drought and temperate climate.
2. **Adoption of high-yielding grafted planting plating materials**
   High-productive varieties like Nagpur mandarin, Khasi mandarin, Chatoki mandarin, and Valencia can be vigorously planted in regions where the production of mandarin is much lower due to climatic conditions.
3. **Adoption of pest & disease resistant varieties**
   Developing and planting disease-resistant varieties can reduce the impact of fungal infections. Citrus greening-tolerant hybrid citrus, Sugar Belle (Killiny*et al*., 2017) can be planted although its potentiality in high altitudes should be examined before planting.
4. **Following IPM for pest and disease management**
   Implementing IPM practices can help control pest and disease outbreaks. Farmers can aggressively use pheromone and light traps for fruit-sucking moths, yellow sticky trap and acceptable fungicides like Bordeaux paste, and lime to control different pests of mandarin.
5. **Following INM**
   As per the age and requirements of the plants, the recommended dose of FYM, NPK and micronutrients like zinc, sulphur, copper, boron, and manganese should be applied. Potassium nitrate (1%) can be used at the end of May, June and July to improve fruit size and production (Meena *et al*., 2024).
6. **Adopting land conservation practices to minimize the impact of landslide**
   It is advised to improve, sustain, and protect the soil carbon pool in extremely susceptible mountain slopes like Darjeeling, Sikkim and Kalimpong areas. Farmers need to implement mixed farming methods to preserve biodiversity and enhance the climatic resilience of mountain agricultural systems. Implementation of a well-designed framework for unproductive land use planning in hilly areas can also optimise their productivity. Implementing intensified afforestation/reforestation initiatives can effectively expand forest coverage, while simultaneously preserving and safeguarding existing forests. These efforts play a crucial role in supporting the long-term viability of temperate fruit-producing systems.
7. **Following mulching for soil moisture**
   Grass or plastic mulching around the base of the trees can help retain soil moisture and regulate soil temperature.
8. **Water smart irrigation practices**
   Efficient irrigation systems such as drip irrigation can help to manage water use during dry periods. Double-ring irrigation in case of non-installation of the drip system can also be used. Micro irrigation in the winter season can also be helpful.

9. **Weather Forecasting**
   Utilizing advanced weather forecasting tools or mobile applications can help farmers plan and manage their activities more effectively as per weather condition.
10. **Sorting and grading for quality**
    Sorting and grading of Darjeeling mandarin fruits are necessary, as they maintain the fruit quality depending on the size of the fruits. However, it needs close supervision, as some farmers will be new to this harvesting technology. It will help to get better market prices and profitability for the farmers.
11. **Post-harvest processing and value addition for more income**
    A little temperature rise can badly impact productivity with related problems of storage and post-harvest handling of produce. So, it is utmost important to give proper care after harvesting. Juices, pickle, candy could also be produced from the mandarin, which could additionally benefit the local farmers economically.
12. **Shifting the time of harvesting and other intercultural operation**
    Farmers must calibrate their field operations and activities to reflect changing climate and crop requirements. As per the changing climatic condition, they should change their sowing time, agronomic management practices and harvesting operation to get optimum yield.
13. **Marketing**
    Creating a strong brand identity for Darjeeling mandarin can make farmers more appealing to consumers. Attractive packaging and branding can differentiate the unique Darjeeling mandarin from its competitors. Partnering with local businesses, restaurants, and health food stores can help to promote mandarin. Highlighting sustainable and organic farming practices can attract environmentally conscious consumers. Besides that, the certifications and eco-friendly packaging can further enhance the demand.
14. **Creation of growers' association**
    Formation of growers' association in the form of FPO or cooperatives can catalyze the collective cultivation, input arrangement and marketing activities. They even get greater input usage, per-acre production, and output pricing. Farmers will have access to wider markets, including export market, through their FPO or cooperatives. This may boost mandarin demand and prices. Together, farmers can negotiate higher product prices and lower input expenses like seeds, fertilizers, and equipment. These associations teach optimal agricultural methods, pest management, and post-harvest handling to boost crop quality and quantity. Sometimes they may get assistance financially and technologically to build need-based infrastructure for production and post-harvest management.
15. **Information sharing**
    The knowledge on climate change and different climate-smart practices on mandarin cultivation for better adoption should be generated among farming communities through different extension programs. Knowledge exchange frequently takes place at the grassroots level, alongside global and regional initiatives. Transferring information from one farmer to another is a highly effective way to share adaptation tactics that are suited to the local context. Farmers acquire and share knowledge and skills, enabling them to adjust to evolving climate circumstances. Farmers' meetings, farmers' field schools (FFS), and Darjeeling mandarin day events should often be organized to educate farmers about pest

identification, types of pest damage, the use of IPM components and climate resilient practices.

16. Avail government schemes

Crop insurance schemes are essential for farmers because they provide coverage for their yield. The primary goal of the crop insurance plan is to alleviate the financial losses experienced by farmers because of the destruction and damage to their crops caused by various hazards, including adverse weather conditions, natural calamities, or income decline owing to variations in agricultural market prices. Farmers can avail of schemes like Pradhan Mantri Fasal Bima Yojana (PMFBY), Weather Based Crop Insurance Scheme (WBCIS), Pilot Unified Package Insurance Scheme (UPIS), Pradhan Mantri Krishi Sinchai Yojana (PMKSY) etc. for better adaptation to climate change led vulnerability.

Conclusion

The climatic conditions of Darjeeling significantly influence the cultivation and quality of Darjeeling mandarin. While the region's temperate climate, adequate rainfall, and unique altitude offer favourable conditions, challenges such as temperature fluctuations, excessive rainfall, and pest management need to be effectively addressed. By adopting appropriate agricultural practices and leveraging the natural advantages of the region, farmers can continue to produce high-quality Darjeeling mandarin, contributing to its reputation and market value. By carefully managing the climatic challenges, the unique flavor and quality of Darjeeling mandarin can be preserved, ensuring its continued significance in the region’s agricultural landscape.

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IFFCO NANO FERTILIZERS PAVE THE WAY FOR SUSTAINABLE AGRICULTURE

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ABSTRACT

IFFCO Nanofertilizers (NFs) offer numerous advantages over conventional fertilizers which include controlled release, targeted delivery, plant growth stimulation, and reduced water and nutrient loss. With the global population expected to exceed 9 billion by 2050, the development of NFs could become essential in meeting the growing demand for food while minimizing environmental impacts. Developing NFs presents an exciting opportunity to revolutionize the agricultural sector and promote sustainable practices. Overall, the development of NFs has led to a significant leap towards sustainable agriculture in India by enhancing nutrient use efficiency and promote environment-friendly agriculture. This paper aims at highlighting the benefits of IFFCO Nanofertilizers to ensure food, nutrition and environment security.

INTRODUCTION

The increasing consumption of fertilizers is not leading to the desired increase in agricultural productivity. The unbalanced use of urea has disturbed the mutual balance of nutrients (nitrogen, phosphorus and potassium). As a result, the nutrient use efficiency is continuously decreasing, affecting soil health, causing environmental pollution, creating crop protection problem and impacting human and animal health. Minimal use of agrochemicals is necessary for sustainable agriculture, which can ensure food, nutrition and environmental security as well as protect the ecosystem and save biodiversity from extinction. If nutrients are used for crop nutrition in the form of nano fertilizers (NFS), then crop production can pave the way for environmentally friendly and more sustainable green agriculture because nano fertilizers have the potential to provide many benefits. Considering the various concerns associated with excessive usage of chemical fertilizers, the declaration of the European Commission to reduce 50% of fertilizers by 2030 is highly appreciable.

The scientists and Industry always look for the products or technologies that help to raise agricultural crop yields while reducing environmental damage. Since NFs minimize the use of chemical fertilizer inputs, they are becoming very popular. The application of nano-fertilizers (NFs) is an emerging research field in agriculture. These are materials in the size range of 1–100 nm that support the nutrition of the plants. NFs offer a number of benefits compared to conventional fertilizers for sustainable and eco-friendly crop production. Some of these mainly include (i) the enhanced absorption and efficient utilization of nutrients without higher losses, (ii) significant reduction of the risk of environmental pollution due to the decrease in the losses of nutrients, (iii) the considerably higher diffusion rate and solubility of NFs compared to the conventional synthetic fertilizers, (iv) controlled release of nutrients in NFs compared to chemical fertilizers in which it is very spontaneous and rapid in case of chemical fertilizers, (v) requirement in low amounts of NFs

than synthetic fertilizers due to reduced loss and higher absorption, and (vi) improvement of soil fertility and also development of a feasible environment for microorganisms.

IFFCO Nanofertilizers

IFFCO explored the innovative approaches to develop nano-urea Plus, nano DAP, nano Zn and nano Cu through nanotechnology to increase NUE for increasing crop yields, produce quality with reduced bulk fertilizers' consumption and increase farmer's profitability at reduced environmental cost. To achieve these objectives, Nano Biotechnology Research Centre (NBRC} at Kalol, Gandhinagar, Gujarat was established by IFFCO on 3rd November, 2019. NBRC has indigenously developed proprietary patented three products – nano urea plus, nano DAP, nano zinc and nano copper. These nano scale nutrients have desired particle shape, particle size, particle purity, composition, concentration, stability, polydispersity index (PDI value), pH and crystal phase. They are bio available and within the scientific limits of application as per their desired content in plants, thus, fulfilling plant nutritional requirement as a fertilizer.

IFFCO Nano urea Plus: IFFCO Nano urea Plus contains 20% N in nanoscale nitrogen particles (30-50 nm) which have more surface area (10,000 times over 1 mm urea prill) and number of particles (55,000 nitrogen particles over 1 mm urea prill). Nano nitrogen particles with pore size (20 nm) can easily penetrate through cell wall and reach up to plasma membrane. Large size particles (30 - 50 nm) can penetrate through stomatal pores. They are also transported via phloem cells through plasmodesmata (40 nm diameter) to other plant parts. They can bind to carrier proteins through aquaporin, ion channels, and through endocytosis and metabolized inside the plant cell. Thus, when applying nanoscale particle like nano nitrogen through foliar application, it leads to more efficient absorption and penetration of nitrogen in-seed production.

Nano DAP (Liquid) : IFFCO Nano DAP is a novel Nano fertiliser notified under FCO (1985), Govt. of India on 2nd March 2023. It contains Nitrogen (8.0% N w/v) and Phosphorus (16.0 % P2O5 w/v). Nano DAP (Liquid) has advantage in terms of surface area to volume as its particle size is less than 100 Nanometre (nm). This unique property enables it to enter easily inside the seed / root surface or through stomata of leaf and other plant openings. Nano clusters of Nitrogen and Phosphorus in Nano DAP (Liquid) are functionalised with bio-polymers and other excipients. Better spread ability and assimilation of Nano DAP (Liquid) inside the plant system leads to higher seed vigour, more chlorophyll, photosynthetic efficiency, better quality and increase in crop yields.

MODES OF APPLICATION OF IFFCO NFs

The appropriate method of NF application is crucial for optimal plant growth, as it varies depending on the soil and climate type. The choice depends on soil quality, nutrient availability, and climate, which affect nutrient uptake and utilization. Understanding these factors and selecting the appropriate method can improve crop yield, reduce environmental impact, and create more sustainable agricultural practices. There are two primary methods of NF application: seed/seedlings priming with IFFCO NFs (Nano DAP, Nano Zn and Nano Cu) and foliar application.

1. Seed/Seedlings Priming with NFs: The Seed/seedlings priming with Nano DAP, Nano Zn and Nano Cu is a pre-sowing treatment that induces physiological changes within seeds/seedlings, allowing for faster germination and radicle length and establishment of seedlings and promoting root and plant growth and development by regulating metabolic and signalling cascades. The method involves soaking seeds in nano DAP @ 5 ml Nano DAP/ kg seed for seed priming and @ 5 ml Nano

DAP/ litre water for seedlings priming for half an hour and then sowing/transplanting. Seed/seedlings priming and foliar spray of Nano DAP within 25-30 days after sowing and 15-20 days after transplanting has shown to reduce application of granular DAP by half while achieving excellent results. Seed priming with Nano Zn and Nano Cu should be done @ 2 ml/kg seeds and of seedlings @ 2 ml/litre of water.

IFFCO NFs act as stimulants, enhancing germination and development by penetrating seed pores, dispersing within, and activating plant hormones that promote growth. Applying nano DAP to seed/seedlings priming increases seed germination and establishment of seedlings by eliminating reactive oxygen species and regulating plant development hormones. Seed/seedlings priming also stimulates the expression of multiple genes during germination, particularly those related to plant resilience, resulting in enhanced resistance. Advanced seed/seedling nano-priming techniques involve applying NFs directly to the seed/seedlings root surface, leaving a substantial fraction impeding pathogen penetration.

Nano-compound absorption at the cellular level reduces input and avoids molecular interactions, allowing for the production of highly resistant seeds with improved germination and seedling growth, especially under stress. Under salt stress, proline, chlorophyll a, and antioxidant enzyme efficiencies are increased significantly compared to untreated, salt-stressed seedlings. NFs mitigate plant stress by regulating internal hormone action in crops, strengthening antioxidants, and reducing reactive oxygen species (ROS) formation.

The foliar application involves spraying NFs directly onto the leaves of plants, allowing for rapid nutrient absorption through the leaf surface. The method is particularly effective when nutrients are required quickly or in regions with low soil fertility. However, foliar application is sensitive to environmental factors such as temperature, humidity, and wind, affecting nutrient uptake efficiency. Seed nano-priming entails coating or soaking seeds in a solution containing NFs before planting. The method promotes rapid germination, stronger seedlings, and enhanced nutrient uptake throughout the plant's life. It is especially beneficial in areas with poor soil quality or where rapid plant establishment is necessary. However, the optimal concentration of NFs must be determined to avoid phytotoxicity. Soil treatment involves incorporating NFs directly into the soil by broadcasting, banding, or localized placement. The method ensures the slow and controlled release of nutrients, reducing nutrient loss through leaching or volatilization. Soil treatment is best suited for regions with high nutrient retention capacities and climates with consistent precipitation patterns. However, the application must be carefully managed to prevent nutrient imbalances or environmental pollution.

2. Foliar Application: Foliar spray is an advanced method that directly applies liquid fertilizers to plants' leaves or foliage, enabling rapid absorption of nutrients through the leaf surface. The method employs NF delivery to the leaf surface for targeted, optimal, rapid, and accurate transfer to the plant. The foliar application of NPs has emerged as a promising method for delivering essential elements such as NFs, fungicides, herbicides, and preservatives to plants. This approach leverages delayed release mechanisms to enhance the effectiveness of these substances. The absorption of foliar-applied NPs can occur through stomata, endocytosis, and direct absorption, although the process heavily depends on particle size. Leaf wax and cell walls can act as barriers, inhibiting the uptake of these particles. Once absorbed, the majority of NPs accumulate in vacuoles. However,

various factors influence the absorption and transport of NPs, including plant characteristics, NP physical properties, and environmental conditions. Foliar application of IFFCO Nano DAP is done 30 days after sowing and 20-25 days after transplanting @4 ml/litre water whereas the foliar spray of Nano Urea Plus is done at critical growth stages at the same rate or say 4 ml/litre water according to N requirement of crops.

Advantages of Foliar Application: The foliar spray offers several advantages over traditional soil applications, including a faster response, improved nutrient utilization, and reduced leaching and run-off. Multiple studies have demonstrated that foliar application of NFs can significantly improve nutrient uptake, promote plant growth, and increase crop yield. The target-based IFFCO NFs are innovative formulations allow for the controlled release and enhanced uptake of nutrients, resulting in increased crop yields and reduced environmental impacts.

THE BENEFITS OF NANO FERTILIZERS

As a result of the steady rise in world population, the demand for agricultural crops has increased drastically. Because of this, farmers have been forced to use conventional fertilizers and pesticides to increase their crop yield which contain chemicals that can be dangerous to both humans and the environment. But in all of this, there's a positive development as well. The need for environmentally sustainable options has encouraged innovation and has led to Nanotechnology being applied to agriculture, thus resulting in NFs. Some of the key benefits of Nano Fertilizers include:

Increased Crop Yield: One of the primary benefits of Nano Fertilizers is that it helps in growing healthier crops. The application of Nano fertilizers has demonstrated substantial increases in crop yields. By ensuring that plants receive the required nutrients precisely when they need them, these fertilizers foster optimal growth conditions, leading to more abundant harvests. The reduction in the excess usage of urea also results in stronger crops and a higher yield. Further, this boost in productivity helps combat food security challenges, especially in densely populated countries, such as India.

Cost Effectiveness: Although, compared to conventional fertilizers that are available in India, Nano fertilizers may seem like an expensive investment. However, their higher nutrient absorption and reduced wastage ultimately lead to cost savings for farmers. Moreover, their long-lasting effects reduce the need for frequent applications, making them more economically viable in the long run.

Environmentally Friendly: Since Nano Fertilizers release nutrients gradually and directly to the plant roots, they minimize the environmental impact of agriculture. Their targeted application also reduces the need for excessive fertilizer use. Thus, the risk of soil and water contamination is reduced, resulting in the preservation of soil fertility and the promotion of sustainable farming practices.

Drought Resistance: Due to India's tropical climate, water scarcity, especially during drought seasons greatly affects its agricultural productivity. Nano Fertilizers can play a vital role in such cases by increasing the water retention capacity of the crops, making them more resilient during dry spells.

Enhanced Nutrients: With traditional fertilizers, a significant portion of nutrients are lost due to leaching or volatilization. On the other hand, Nano Fertilizers encapsulate nutrients and protect them from being destroyed. This leads to improved nutrient absorption by plants, maximizing their growth potential and goes hand in hand with increased crop yields.

Nano Pesticides Synergy: One of the major advantages of Nano fertilizers is that they can be tailored to release nutrients and pesticides simultaneously. This has led to the development of "smart fertilizers" that not only nourish plants but also protect them from pests and diseases.

Easy Penetration and Controlled Release of Fertilizers*:* NFs significantly aid the penetration of fertilizers into plant tissues, enhancing nutrient uptake and utilization by plants due to a high surface area–to–volume ratio. NPs can quickly diffuse through plant cell walls and membranes and the functionalization of these NPs with specific targeting molecules enables them to be selectively taken up by plant tissues, ensuring a precise delivery of essential nutrients. The improved penetration reduces the amount of fertilizer required and minimizes nutrient leaching and runoff, thereby mitigating environmental pollution and increasing nutrient uptake which contributes to better crop yields, improved nutritional quality, and overall agricultural sustainability.

High Nutrient Absorption Efficiency: NFs increase fertilizer efficacy and the ratio of soil nutrient absorption in crop yield, hence decreasing fertilizer use. Additionally, NFs prevent fertilizer leaching loss.

Effective Duration of Nutrient Release: The effective duration of nutrient release in NFs has significant implications for agricultural productivity and sustainability. It ensures that plants receive the necessary nutrients throughout the growth cycle. Moreover, the controlled release of nutrients minimizes nutrient losses, reducing the need for repeated fertilizer applications and mitigating environmental pollution. Bulk fertilizers are only effective for a short time after application. Several studies have investigated the effective duration of nutrient release in NFs.

Improved Microbial Activity: The interaction between NPs and microorganisms, the shelf life of biofertilizers, and the dissemination of NFs are among the most crucial variables in plant growth. NFs combine NPs and living microorganisms designed to improve plant growth and yield by enhancing nutrient uptake and soil fertility. They improve the structure and function of soil and the morphological, physiological, biochemical properties and yield attributes of plants. The formation and application of NFs is a practical step toward smart fertilizer that enhances growth and augments the crop yield.

Improved Soil Activity: NFs increase soil activity by providing efficient delivery of nutrients to the root zone. They increase the activity of soil microorganisms, leading to improved decomposition of organic material and increased nutrient cycling]. NFs increase the nitrogen mineralization rate in soil, a crucial process for maintaining soil fertility. NFs improve the activity of soil bacteria and fungi, essential fo**r** maintaining the soil ecosystem.

Improved Soil Water-Holding Capacity: NFs improve soil structure and water-holding capacity, increase organic matter, and create favourable conditions for beneficial microorganisms. NPs bind soil particles and reduce water loss through runoff and evaporation, resulting in better crop yields and improved soil health.

Eco-friendly Nature*:* Traditional fertilizers release large amounts of N and P into the soil, which can cause eutrophication and algal blooms in nearby water bodies. However, NFs being more efficient,

are much safer for the environment because they are designed to release their nutrients slowly over time. These fertilizers are required in much less amount thus farmers can save money on fertilizer costs. Increased availability of other nutrients ensures balanced nutrient supply to the plants.

Low Production Cost: NFs could attain lower production costs due to enhanced nutrient use efficiency, controlled release, and targeted delivery, reducing the wastage of fertilizers in the field and ensure higher nutrient absorption rates than traditional fertilizers.

Fulfils the Goal of Precision Farming: The use of NFs for precision farming offers several potential benefits. Directly applied NFs can enable a more precise application than traditional fertilizers thus reducing nutrient losses through different pathways and by other substances in the plant, such as micronutrients and growth regulators.

Improves Plant Stress Tolerance*:* Plants respond to abiotic stress by altering gene expression at the molecular level. Several studies show that the signalling system in plants excites the defence machinery, which activates molecular mechanisms to respond such as drought or extreme temperatures by providing essential nutrients that help plants remain healthy despite water shortages or heat waves and by offering beneficial protective compounds, such as antioxidants, that can help plants cope with environmental stressors. NFs may also help plants better tolerate to diverse stress circumstances by modifying genetic, biochemical, and physiological pathways and strengthen their defence against environmental stresses in various phases. The nanoscale particles of the fertilizers can penetrate the cell walls of plants, allowing nutrients to reach the root system and other parts of the plant more quickly.

Stimulates Plant Growth: NPs increase nutrient availability allowing plants to utilize them more efficiently for the growth and development, improve soil structure and water retention, create a protective layer on the soil surface, which can help to reduce the loss of essential nutrients, help maintain the soil pH balance and reduce the amount of fertilizer runoff which otherwise can harm the environment thus positively affecting plant growth. All these factors help in stimulating plant growth.

PROSPECTS OF IFFCO NANO UREA PLUS, NANO DAP, NANO ZINC AND NANO COPPER

IFFCO nano urea Plus, Nano DAP, Nano zinc and Nano copper are in sync with OECD testing guidelines (TGs) and "Guidelines for Testing of Nano Agri inputs (NAIPs) and Food Products released by the Department of Biotechnology, Government of India. Harvested produce of crops applied with IFFCO's nano urea, nano zinc and nano copper have been found to be fit for consumption with no adverse effect. These are safe for application, both to the user and for the environment. These have other incremental benefits such as these are cost-effective and can be applied in rainfed and dry land agriculture as well as in protected cultivation. These are also compatible with most of the agrochemicals, bio-stimulants and specialty fertilizers. Independently, nano nitrogen, nano zinc and nano copper have also been proactively tested for bio-efficacy, biosafety-toxicity and environment suitability by NABL-accredited and GLP certified laboratories. IFFCO NFs meet all the current national and international guidelines related to nanotechnology or nano scale agri-inputs. It is for the first time in the world that nano Nano Urea Plus, Nano DAP have been introduced and provided to the farmers. With inclusion of IFFCO nano- fertilizers such as Nano Urea Plus, Nano DAP, Nano Zn and Nano Cu in the schedule VII of FCO 1985, and the production of Nano Urea Plus and Nano DAP farmers are ultimately benefitting from the boon of nanotechnology. It is, indeed, a step in the direction of self-reliance in terms of '*Atmanirbhar Bharat'* and *'Atmanirbhar Krishi'* because of IFFCO NFs.

IFFCO MEGA CAMPAIGN FOR PROMOTION AND APPLICATION OF NANOFERTILIZERS

It is high time that the benefits of nano fertilizers like Nano Urea Plus Liquid and Nano DAP Liquid are demonstrated and promoted for application by the farmers for eco-friendly sustainable green agriculture. To create greater awareness about the benefits of nano fertilizers and increase their usage by making them available to every village to achieve the goal of food, nutrition and environment security IFFCO has initiated *"IFFCO Mega Campaign for Promotion and Application of NFs"* from July 1, 2024. The goal of this mega project is to create greater awareness about the benefits of adoption of NFs and develop trust among the farmers to use NFs ensuring reduction in conventional fertilizer use by 50%. For this purpose, IFFCO has selected 201 number of "Model village clusters" with minimum 2000 acres of cultivated area in each cluster across the country during 2024-25. However, it will be 500 acres in case of hilly states. The gross cropped area under the project for entire year will be around 8 lakh acres and the net area will be 4 lakh acres per season. Nano village clusters have been established near to the location of Drone Didi/Drone entrepreneur for effective scheduling of spray within two days from the date of purchase for which one or two Drone Didi/Drone Entrepreneurs can be connected with Nano Village Cluster. Each cluster has been linked with IFFCO fertilizer Sale Point (IFFCO Farmers Service Centre/IFFCO E. Bazar/Fertilizer Sale Point of Cooperative Society). Provision has been made to provide Nano Urea Plus, Nano DAP and Sagarika at 25% subsidized rate to the farmers of the project area. This discount will be given to the farmers through retail points which will be mapped with village clusters. Further, for foliar spray of these fertilizers through Drone, IFFCO will contribute Rs. 100 per acre per spray to the Drone Didi/Drone entrepreneurs and rest will be paid by the farmer. States will define total land area of farmer under Nano Village Project and also mention crop names (season wise) for setting up of permissible limits of purchase by the farmers from IFFCO's Fertilizer Sale Centres. The timeline of this project will be 3 years. For better communication and awareness about this project, Nano village cluster should be near to the active sales point (IFFCO FSC/ IFFCO Bazar etc). Nano village clusters have been selected from potential belt of major crops of the state.

FUTURE OUTLOOK

- Efforts are to be made to design formulations that enable the controlled release and targeted delivery of nutrients using "smart" NFs that can respond to specific environmental cues, such as pH or temperature, to release nutrients when and where they are needed. This approach can help reduce nutrient losses and enhance plant nutrient use efficiency, promoting sustainable agricultural practices.
- Integrating nano-sensors into NFs could enable real-time soil nutrient level monitoring, allowing for precise application and reduced nutrient waste. This technology can help farmers apply the correct amount of fertilizer at the right time, thus improving crop yields and reducing environmental pollution.
- Education and outreach initiatives targeting farmers and other stakeholders are critical in fostering the acceptance and use of NFs in agriculture, which can be achieved through disseminating information about the benefits of NFs and their safe and effective use.
- Despite the potential benefits, much research is needed to optimize nanomaterial composition and release rates and develop scalable and cost-effective production methods. Addressing these challenges will make NFs accessible and affordable for farmers worldwide,

especially in developing countries where food security and sustainable agriculture are pressing concerns.

- While the potential benefits of NFs are significant, addressing the potential risks associated with their application, such as human health, environmental, and ecological risks, is essential.
- Developing regulations and guidelines for their safe and responsible use will ensure agricultural sustainability and protect human health and the environment.
- Interdisciplinary collaboration between researchers, agricultural experts, and policymakers is vital for developing and implementing NFs. This collaboration will facilitate knowledge exchange, improve the understanding of the implications of NFs in the agricultural ecosystem, and help develop best practices for their usage.
- Educating farmers about the advantages, application methods, and potential risks of using NFs will enable them to make informed decisions about adopting these innovative products in their farming practices.
- Continuous monitoring and assessment of the impacts of NFs on crop yields, soil health, and the environment is necessary to make data-driven decisions and adjustments as technology advances, which will ensure that the benefits of NFs are maximized while minimizing negative consequences.
- Future research should focus on refining the delivery mechanisms, exploring new materials and strategies for controlled release, and assessing long-term effects on human health and the environment. Ultimately, the successful integration of NFs into modern agricultural practices can revolutionize how we approach sustainable agriculture, ensuring global food security while minimizing our ecological footprint.
- Precision agriculture, involving drones fitted with cameras to acquire multispectral pictures detecting nutrient concentration in the field, can help farmers avoid wasting precious resources by accidentally applying too much to their crops or too often. To this end, a life cycle assessment of nanoparticles could provide a holistic evaluation of their application by considering their yield productivity, environmental implications, and effect on food chains.
- By focusing on ongoing research, addressing potential risks, fostering interdisciplinary collaboration, educating farmers, and ensuring affordability and accessibility, the potential of NFs to contribute to global food security and agricultural sustainability significantly can be realized.

THE ROAD AHEAD

To ensure the supply of nano fertilizers to farmers, IFFCO has set a target of selling 400 lakh bottles of Nano Urea Plus (liquid) and 200 lakh bottles of Nano DAP (liquid) in the year 2024-25. Through its "Mega Campaign" IFFCO will ensure the availability of Nano Urea and Nano DAP in every village of the country for environment friendly food and nutrition security. To ensure the use of nano fertilizers in every field and every crop, farmers will be encouraged to use these smart fertilizers by providing them proper information about the importance and benefits of these smart fertilizers. “IFFCO's Nanofertilizers Promotion Mega Campaign” will definitely help in creating confidence in farmers about the importance of nano fertilizers, which will pave the way for environment friendly green agriculture in the country.

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CURRENT STATUS OF HYPOPHYSATION TECHNIQUES USED IN WEST BENGAL FOR SUSTAINABLE SEED PRODUCTION

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Introduction

Fish farming, or aquaculture has become an essential part of the agricultural economy in India, particularly in West Bengal, which is one of the leading state in fish production. With a significant demand for fish both domestically and globally, enhancing and improving fish breeding techniques has been critical for meeting growing market needs. One of the most important and traditional method employed in fish breeding is hypophysation, or the artificial induction of spawning in fish using pituitary extract containing gonadotropins (FSH, follicle stimulating hormone and LH, luteinizing hormone). Hypophysation technique plays a pivotal role in increasing the seed production of commercially valuable fish species, especially Indian major carps like Rohu, Catla, and Mrigal, which are extensively farmed in different parts of West Bengal. Indian major carps have a major share in the fish liking diet of West Bengal, which is available in the rates of Rs 150 to 300/kg according to the size or fresh/frozen state of the harvested fish. This hypophysation technique is vital in finfish hatchery management and helps fish farmers ensure a steady and controlled supply of fish larvae for stocking in ponds and tanks.

Indian major carps breed once a year during the early monsoon season (June and July). At that time, the collection of spawns from natural sources is insufficient for our population. To overcome this situation, induced breeding is the most effective process to increase and promote carp culture in the state. Though several other inducing agents are used for fish breeding, hypophysation technique is still improved and advanced in different countries including India.

Historical Development of Hypophysation in West Bengal (Traditional Practice):

Due to the highly fish dependent diet of West Bengal and rapidly growing population during post independence era, the demand of fresh fishes grew to such extent which could not be met by capture catch. Also, the seed requirement in different parts of West Bengal is very high. Natural breeding was unpredictable, seasonal, and dependent on favorable environmental conditions such as monsoon rains and water flow, which often limit fish seed production. Fish pituitary gland contains different hormones of which pituitary gonadotropins are very important in controlling the gametogenesis in aquacultured fish.

Early Development (1950s - 1960s)

The breakthrough came when Indian fisheries scientists successfully induced spawning in Indian major carps (Rohu, Catla, and Mrigal) using fish pituitary gland extracts. The Central Inland Fisheries Research Institute (CIFRI), located in West Bengal, was at the forefront of this research. Previous trials using mammalian pituitary extract failed to induce successful maturation and spawning in captivity. Also, the availability of pituitary glands specifically from teleost fish was limited during this period.

Scaling Up (1970s - 1980s)

By the 1970s, hypophysation technique became more widespread, particularly in the state of West Bengal and Tamil Nadu, which emerged as a key hub for freshwater aquaculture. Fish farmers in the state began to adopt the technique on a large scale, leading to a boom in fish production, mainly using the glands collected from mature fish.

Dr. Hiralal Chaudhuri and his team preparing the fish for adoption of hypophysation technique (Source: Google Images)

Advancements (1990s - Present):

In the 1990s, hypophysation techniques saw further refinement with the introduction of synthetic gonadotorpins like HCG (Human Chorionic Gonadotropin) and GnRH based analogues (Ovaprim, Ovatide and WOVA-FH). These hormones offered a more efficient, reliable, and cost-effective way of inducing spawning compared to the crude pituitary extracts used earlier. However, still West Bengal fish farmers prefer to use pituitary gland extract for induced breeding. There are young professionals who are trained and expert in fish pituitary gland collection and are involved in selling the pituitary gland to fish farmers at Rs. 2-3/gland. Depending on the location and size of the fish, pituitary gland price may vary. The first author personally visited the fish market of West Bengal and saw the availability of pituitary glands for fish breeding and it is worth mentioning that the hypophysation technique is still widely practised and adopted in West Bengal for seed production of multifish species.

Preservation of Pituitary

Preservation of the pituitary is a very important phase in fish pituitary extract preparation. In Dum Dum Railway Station fish market of West Bengal, the isolated fish pituitary are transported to many regions of North 24 Parganas district (Dum Dum, Sodepur) and Burdwan district (Kalna) by train, so the proper preservation of the fish pituitary is necessary for a fruitful result. In this connection, it would be good to establish a fish pituitary gland bank in West Bengal and Tamil Nadu states. Pituitary preservation is done using either alcohol or acetone. In alcoholic preservation, an isolated pituitary is transferred immediately to the solution and stored in room temperature. To preserve target hormones of pituitary extract, pituitary gland is immediately transferred into absolute alcohol for dehydration, then washed with alcohol and poured into absolute fresh alcohol after one day. In the case of acetone, the pituitary gland is kept at -20°C for two days with chilled fresh acetone, and the acetone solution is changed every 8-12 hours. Pituitary gland preseservation should be taken care as few dintegrated glands during collection would result in poor response in fish after injection of fish pituitary extract.

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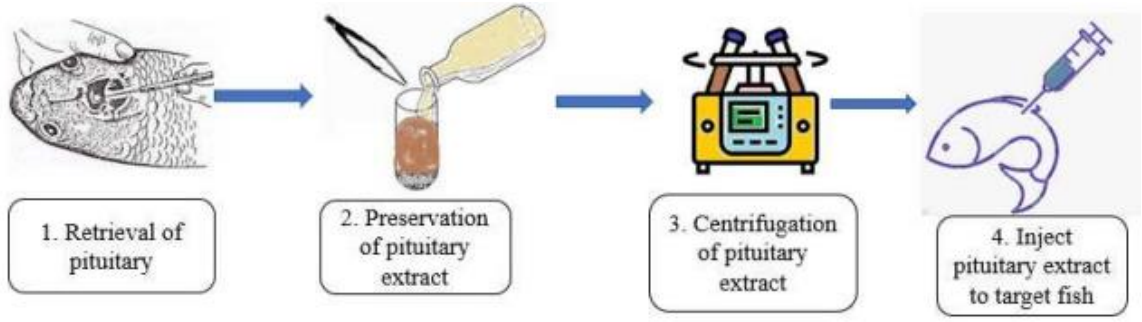
Collection of fish pituitary gland from the base of the hypothalamus (Source: https://doi.org/10.52756/ijerr.2022.v29.008)

Extract formation

Isolated pituitary gland kept in a 2 ml beaker with 0.9% normal saline solution. Now the prepared solution goes for centrifugation, and after completion, the supernatant is collected for injection. Extract preparation occurs immediately before the injection (Surnar *et al*., 2015).



Processing of pituitary gland for preparation of pituitary extract for injection to fish (Source: Google Images)

Dosage of pituitary extract

In the case of coelomic injection, it is injected below the pectoral fin in a scaleless area. This procedure is difficult because the heart is located near the pectoral fin, where it can result in injury (Surnar *et al*., 2015; Khan and Ali, 2021). Muscular injection, on the other hand, is injected at a 45° angle between the dorsal and lateral lines of the scale (Surnar *et al*., 2015; Khan and Ali, 2021).

Pituitary extract dose for Indian major carps

To adjust the dose in hypophysation technique, accurate weighing of pituitary glands are required. The first dose in female fish is 2-4 mg/kg body weight, and the second dose is 6-8 mg/kg body weight, given 5-6 hours after the first dose. Males receive the first dose during the second dose of females at a rate of 2-3 mg/kg of body weight (Surnar *et al*., 2015; Tiwana and Raman, 2012; Hossain *et al*., 2012; Brzuska and Adamek, 1999). The dose also depends on the fish's maturation, sex, age, and environmental condition (Tiwana and Raman, 2012; Hossain *et al*., 2012; Brzuska and Adamek, 1999).

Conclusion and future perspectives

In conclusion, hypophysation technique is still practised in different parts of West Bengal for sustainable seed production and hatchery management. A major bottleneck in this method is non-

availability of quality pituitary glands from mature fish and non-availability of separate fish pituitary gland bank as that of semen bank for farmed animals. There is a scope for establishment of fish pituitary gland bank for fish seed production in the country particularly in the states where freshwater aquaculture is widely practiced. Also, availability of pituitary glands throughout the year will enable production of purified gonadotropins for fish breeding. In the future, there is scope for production and utilization of recombinant fish gonadotropins for fish breeding as lot of Indian cultured fishes have been sequenced and the details are available in gene bank.

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CURRENT TRENDS IN FOOD PACKAGING AND THEIR IMPACT IN REDUCING POSTHARVEST LOSSES

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Summary
This subject delves into the impact of food packaging technology advancements on minimizing food waste and spoilage post-harvest. It delves into recent developments such as biodegradable materials, nanotechnology, hermetic storage solutions, and active and intelligent packaging systems. The analysis emphasizes how these technologies enhance the longevity and quality of food items, ultimately cutting down on postharvest losses. It also evaluates the efficacy of these packaging solutions.

Introduction
The global food system faces significant challenges with post-harvest losses being a critical issue that undermines food security, economic stability, and sustainable development (Olakiumide, 2021). In Africa, where hunger, malnutrition, and limited access to nutritious foods are already challenges, post-harvest losses further exacerbate food security issues (Dube et al. 2023). Developing countries are particularly affected due to inadequate storage, handling, and transportation infrastructure, leading to substantial food wastage (Yahia et al. 2019). To meet the needs of the rapidly growing world population while ensuring long-term sustainable development, addressing post-harvest losses is essential (Benedicta Adewoyin, 2023). Additionally, advanced packaging technologies have been developed to extend the shelf life of food products and maintain their nutritional value (Pereira de Abreu et al. 2012). This is a crucial step in reducing the environmental footprint of food production and enhancing food availability without the need for additional agricultural inputs (Shafiee-Jood and Cai, 2016).

Food packaging is crucial for maintaining food quality, safety, and shelf life, but it also contributes significantly to waste generation (Cheng, 2023). This has led to a growing demand for sustainable food packaging solutions that minimize environmental impact while meeting consumer needs (Cheng, 2023). Innovative sustainable packaging aims to reduce food waste and loss by preserving food quality and addressing food safety concerns related to food-borne illnesses and chemical contamination (Jimenez Rincon et al. 2022). These solutions, including advanced technologies such as active and intelligent packaging, biodegradable and biobased polymers, hermetic storage, and nanotechnology, are transforming the food packaging industry by extending the shelf life of food products and reducing spoilage (Yan et al. 2022; Onyeaka, 2022; Akhila et al. 2022). These cutting-edge technologies not only preserve the physical and chemical properties of food but also offer sustainable alternatives to traditional packaging materials (Majid et al. 2018).

Active packaging
Active packaging involves incorporating secondary elements into or around the packaging to enhance its performance. This approach aims to reduce postharvest losses of fruits and vegetables

by using oxygen scavengers, moisture regulators, antimicrobial agents, and ethylene absorbers to maintain quality and extend shelf life (Robertson, 2005; Samad and Zahra, 2016; Barbosa *et al*., 2014). Oxygen scavengers reduce oxidative spoilage, moisture regulators control humidity, ethylene absorbers delay ripening and antimicrobial packaging releases agents to inhibit microorganisms (Cichello, 2015; Jain *et al*., 2017; Gaikwad *et al*. 2019; Zhang *et al*. 2022). Natural antimicrobial agents, including essential oils and plant extracts, have been integrated into packaging films to bolster their antimicrobial capabilities (Ribeiro-Santos et al. 2017). Furthermore, studies have demonstrated that chitosan-based films exhibit substantial antimicrobial activity against prevalent spoilage microorganisms (Wrońska et al. 2021).

Intelligent packaging

The concept of active packaging involves integrating secondary elements into or around packaging with a specific purpose. Intelligent packaging represents a significant advancement over traditional packaging, offering an effective means of monitoring food adulteration throughout the supply chain (Dobrucka and Cierpiszewski, 2014). This type of packaging allows for continuous monitoring of food quality, utilizing sensors to detect and record internal and external alterations in the product's environment. It can transmit this information to end-users or indicators that monitor quality indicator compounds or environmental conditions (Heising et al., 2014). Intelligent packaging employs various mechanisms for monitoring food quality. Time-Temperature Indicators (TTIs) track the cumulative time-temperature history of packaged products, providing insight into potential compromises to their quality (Simpson et al., 2012). These indicators are particularly valuable for monitoring the cold chain during transportation and storage. According to Zhang et al. (2016), TTIs play a crucial role in reducing postharvest losses by ensuring that produce is stored and transported under optimal conditions. Gas indicators are designed to detect changes in the atmospheric composition within the packaging, such as variations in oxygen, carbon dioxide, and ethylene levels. These indicators can alert consumers and retailers to potential spoilage or contamination (Mills, 2015). Freshness indicators offer visual cues regarding the freshness of the product, often through color changes and can detect alterations in biochemical markers correlated with product quality (Kuswandi, 2020; Luo et al., 2022).

Biodegradable and bio-based polymers

Biodegradable and bio-based polymers are being recognized as sustainable alternatives to traditional plastics in food packaging (RameshKumar et al. 2020). Derived from renewable resources, these materials decompose naturally, thereby reducing their environmental impact (RameshKumar et al. 2020). Their application in food packaging has demonstrated significant potential in reducing postharvest losses of fruits and vegetables by extending shelf life and preserving quality (Jena and Saryam, 2023). Biodegradable polymers, such as polylactic acid (PLA), polyhydroxyalkanoates (PHA), and starch-based materials, are derived from renewable resources (Rajeshkumar, 2022). Studies have indicated that PLA-based films can effectively prolong the shelf life of fresh produce by serving as a barrier to moisture and gases (Mistriotis et al. 2016). Bio-based polymers, sourced from plants and agricultural waste, have been shown to significantly reduce postharvest losses by maintaining the quality of fruits and vegetables during storage and transportation (Versinoet al. 2023). The incorporation of nanoparticles into biodegradable polymers can enhance their mechanical and barrier properties. Nanocomposites made from PLA and nano clay have demonstrated the ability to improve the shelf life of fresh produce by reducing oxygen permeability and microbial growth (Sharma et al., 2020).

Nanotechnology

Nanotechnology has become a game-changing innovation in the agricultural industry, particularly in addressing postharvest losses of fruits and vegetables (Kim et al. 2018). By harnessing the unique properties of nanomaterials, this technology offers novel solutions to postharvest management produce (Torres-Giner et al. 2020).

Nanocoatings are ultra-thin layers of nanomaterials applied to the surface of fruits and vegetables to create a protective barrier against moisture loss, gas exchange, and microbial contamination (Hussain et al. 2024). These coatings can be crafted from a variety of nanomaterials, including chitosan, silver nanoparticles, and zinc oxide nanoparticles (Muiz et al. 2022). Research indicates that nanocoatings can significantly prolong the shelf life of fresh produce by inhibiting microbial growth and delaying ripening (Mihindukulasuriya and Lim, 2014). Nanosensors are utilized to monitor the real-time quality and safety of fresh produce (Sundramoorthy et al. 2022). These nanosensors can detect changes in temperature, humidity, gas composition, and the presence of pathogens (Kumar et al. 2017). For instance, ethylene nanosensors can aid in managing the ripening process of fruits, thereby extending their shelf life (Qadri et al. 2018). Nanopackaging entails integrating nanomaterials into packaging materials to enhance their mechanical and barrier properties (Kuswandi and Moradi, 2019). Nanocomposites made from materials such as PLA and nanoclay have demonstrated the ability to improve the shelf life of fresh produce by reducing oxygen permeability and microbial growth (Basumatary et al., 2022). Nanoemulsions are employed to deliver antimicrobial agents and other active substances to the surface of fruits and vegetables (Hussain et al. 2024). Studies have shown that nanoemulsions can effectively mitigate microbial contamination and extend the shelf life of fresh produce (Al-Tayyar et al. 2020).

Hermetic Storage Solutions

Hermetic storage solutions have proven to be highly effective in reducing postharvest losses, especially in developing countries (Kumar and Kalita, 2017). These solutions involve creating airtight conditions that prevent the growth of pests, mold, and fungi, thus preserving the quality and safety of stored grains and other agricultural products (Navarro, 2012). Mechanisms of Hermetic Storage Hermetic storage creates an oxygen-depleted environment, which inhibits the growth of aerobic organisms like insects and fungi (Navarro et al., 2024). This is achieved through the use of airtight containers or bags that prevent the exchange of gases with the external environment (Kumar and Kalita, 2017). By maintaining a stable internal environment, hermetic storage solutions prevent moisture ingress, crucial for reducing mold growth and mycotoxin contamination (Diarra, 2016). They can also regulate temperature fluctuations, which can lead to condensation and spoilage if not controlled, achieved through the use of insulated materials and controlled storage conditions (Kumar and Kalita, 2017; Okolo et al., 2017).

Conclusion

The latest developments in food packaging, including the use of cutting-edge materials, smart packaging technologies, and sustainable practices, are crucial in reducing postharvest losses. Innovations such as biodegradable films, active and intelligent packaging, and enhanced sealing methods contribute to extending shelf life, preserving food quality, and minimizing spoilage. These advancements not only enhance food safety and minimize waste but also play a role in creating more sustainable food systems by optimizing resource utilization and reducing environmental impact. As these technologies continue to advance, they offer the potential to further decrease postharvest losses and enhance global food security.

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DEFEAT DIABETES BEFORE IT STARTS: YOUR GUIDE TO PREVENTION

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Did you realize that diabetes affects more than 420 million individuals globally? In India, a staggering 77 million adults over 18 are afflicted with type 2 diabetes, and nearly 25 million are prediabetic, placing them at a heightened risk of developing the condition shortly. Alarmingly, more than 50% of those affected are unaware of their diabetic status, which can lead to severe health complications if not detected and treated early. Diabetes significantly elevates the risk of heart attacks and strokes, with affected individuals facing a two- to three-fold increase in these life-threatening events. These rising incidents of diabetes mellitus is a matter of concern not only in India but all over the world. Hence there's a great need to create awareness regarding the same. It's important to prevent it and maintain your blood sugar levels to avoid complications which are a matter of concern in our day to day life.

Before discussing about preventive strategies let's learn about "What is Diabetes?" Diabetes Mellitus (DM) is a metabolic disorder that occurs due to defective production or action of insulin which is the underlying cause of diabetes. It is the spike in blood sugar levels due to the insufficient secretion of insulin by the beta cells of pancreas. It is mainly of two types including Type 1 Diabetes and Type 2 Diabetes.

Type 1 diabetes mellitus is also known as Insulin Dependent Diabetes Mellitus (IDDM) as there is no or little production of insulin due to the destruction of beta cells by autoimmune response. These individuals require daily insulin injections otherwise the conditions may worse. It occurs in children or adolescents hence also termed as Juvenile diabetes. Whereas Type 2 diabetes mellitus is known as Non-Insulin Dependent Diabetes Mellitus (NIDDM) in which the pancreas is unable to produce enough insulin or it is unable to do so effectively resulting in increased levels of blood sugar. This type of diabetes can be maintained by exercise and diet. It occurs in adults hence called as adult onset diabetes mellitus. There are also other types which are Gestational Diabetes Mellitus (GDM) and Malnutrition Related Diabetes Mellitus (MRDM). GDM is the DM which results in increased blood sugar levels in pregnancy whereas MRDM is the DM which occurs in malnourished individuals in which the person is unable to produce insulin due to the undernourishment.

Although diabetes can cause various issues like increase in thirst (polydipsia), increased appetite (polyphagia), frequent urination (polyuria), dizziness, drowsiness, low energy levels, weakness, blurred vision and weight loss. But along with these symptoms, it can also leads to various complications which can even be recognized as fatal. These complications can affect eyes, kidneys and even nervous system. Therefore, taking proactive steps to prevent diabetes is crucial, as early action can significantly reduce the risk of developing this chronic condition. Embracing the principle that "Prevention is better than cure" it is essential for maintaining long-term health. Here are some of the strategies which can prevent diabetes.

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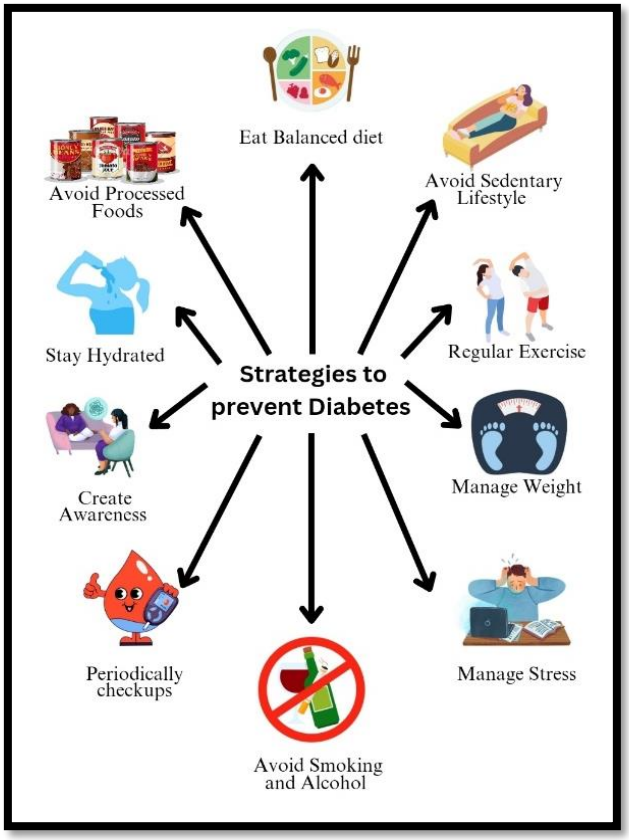

Fig. 1 Strategies to prevent Diabetes

1. **Balanced diet**: Having balanced diet is one of the key strategies to prevent ones from obesity which is the leading cause of various diseases including diabetes. Consuming a sufficient quantity of macro- and micronutrients in your diet will support a healthy lifestyle and shield the body from illness. Eat a diet rich in fruits and vegetables. Consume foods high in quality protein, such as eggs, lentils, and beans. By incorporating nuts and seeds into the diet, one can incorporate high-quality fat that is low in saturated fats and high in mono-or polyunsaturated fatty acids. For optimal diabetes management, it is essential to limit simple sugars due to their rapid absorption and high glycaemic index, which cause harmful blood sugar spikes. Instead, focus on complex carbohydrates and dietary fiber. Avoid simple carbohydrates including sugar, *gur*, *shakkar*, honey, banana, mango, pomegranate, *cheeku*, grapes, potato, *arbi*, *shakkarkandi*, *zimikand*, *chukunder*, *murraba*, glucose syrups etc. Incorporate millets and choose whole grains over refined cereals. It's a common misperception that it is only sugar which one has to avoid during diabetes but it's not the case. One has to avoid all the food products which have high glycemic index and high glycemic load which will further increase the blood sugar levels. It's important to remember that managing diabetes involves controlling portion sizes rather than solely focusing on the type of grain consumed. So for someone with diabetes, food management is crucial, but maintaining a well-balanced diet is also necessary to ward off illness.
2. **Avoid Sedentary Lifestyle**: Performing no work and living a sedentary lifestyle is very common nowdays. This can cause increase in weight which further causes obesity that is the leading cause of diabetes due to the inactive lifestyle. So including exercise in your daily routine will

help to prevent ones from diabetes. Remember, “Consistency is key” in maintaining a healthy lifestyle and reducing diabetes risk.

3. **Regular Exercise**: When it comes to exercise, “move it or lose it” takes on a new meaning. Frequent exercise lowers blood glucose levels, improves insulin sensitivity, and helps in weight management. 150 minutes of moderate intensity exercise each week decreased the incidence of type 2 diabetes by 58% in high-risk persons, according to research from the Diabetes Prevention Program (DPP).
4. **Weight management**: Maintaining a healthy weight is essential for preventing metabolic problems. Maintaining a healthy weight with a balanced diet lowers the risk of obesity and also lowers the occurrence of type 2 diabetes. For optimal diabetes control, use a blend of oils like sunflower, corn, and groundnut oil rather than single oils, avoiding those with saturated and trans fats (animal fat and hydrogenated fat). Opt for fish and chicken over red meat, and restrict fried foods. It is important to prioritize plant-based proteins, which are cholesterol-free and fibre-rich, and enjoy mixed, unsalted raw or dry-roasted nuts for balanced blood glucose and lipid levels without weight gain.
5. **Stress management**: One of the most important risk factors that can contribute to diabetes in the expanding population is the rising levels of stress in today's environment. Diabetes can be avoided by practicing yoga, meditation, and stress management techniques. Individuals who experience depression and stress are more likely to develop diabetes because these conditions can be caused by hormonal changes in the body, which in turn can lead to metabolic problems such as diabetes. Cortisol and other stress hormones can interfere with insulin’s ability to function as intended. Engaging in your favorite pastime and getting eight hours of restful sleep each night will help you manage your stress.
6. **Avoid smoking**: In addition to damaging your lungs, smoking raises your chance of getting diabetes. Type 2 diabetes is 30–40% more common in smokers than in non-smokers. Giving up smoking lowers risk and enhances general health, especially cardiovascular health, which is frequently impacted by diabetes.
7. **Avoid alcoholism**: Alcohol should be avoided, incorporating probiotics into your diet may enhance insulin sensitivity and reduce inflammation, contributing to better blood sugar control.
8. **Education**: Creating awareness and education plays a major role in preventing diabetes. It is crucial to run public health programs that inform people about the risk factors and lifestyle modifications needed to prevent diabetes. High-risk populations should be the focus of these initiatives, which should also stress early detection and intervention. Access to preventive healthcare, a healthy diet, and physical activity are all greatly impacted by government policies that support them and can help prevent diabetes.
9. **Avoid Fasting**: Inappropriate or excessive fasting practices have the potential to aggravate insulin resistance, interfere with normal metabolic processes, and encourage unhealthy eating habits, all of which can lead to the development of diabetes. It’s crucial to proceed cautiously when fasting, particularly for those who are controlling or at risk of diabetes, and to speak with medical professionals before beginning any fasting program. One misconception is that fasting can be compensated by eating more lately. However, fasting can lead to dangerous hypoglycaemia (low blood sugar), especially for those on oral medications or insulin. To maintain stable blood sugar levels, it is crucial to eat frequent, balanced meals—ideally six small meals a day—rather than large, infrequent ones.

10. **Regular health checkups**: It is crucial to get periodic screenings in order to prevent diabetes. In order to reduce the risk of developing diabetes, people should get their HbA1c checked at least once every three months, especially if they are pre-diabetic.
11. **Stay Hydrated**: In addition to being beneficial to your general health, drinking lots of water can help you control your blood sugar levels. Sugary beverages should be avoided since they raise the risk of diabetes and cause weight gain, such as sodas and sweetened teas. Stick to water, herbal teas, or sparkling water flavored with a squeeze of lime or lemon.
12. **Avoiding processed and artificial sweeteners**: Incorporating the avoidance of processed and artificial sweeteners into your lifestyle can significantly support diabetes prevention. These sweeteners, often found in sodas, candies, baked goods, and even some “health” foods, can lead to spikes in blood sugar levels and contribute to insulin resistance over time.

Remember, "Snack smart, not just on a whim." Choosing snacks wisely, such as opting for nuts and vegetables, can make a significant difference in managing diabetes effectively. To effectively manage and prevent type 2 diabetes, adopting a holistic approach that includes dietary adjustments, exercise, and lifestyle changes is crucial.

While there are many uncontrollable causes of diabetes, including genetic ones, so these measures may not guarantee that you will never develop this metabolic illness. But always remember, “An ounce of prevention is worth a pound of cure” So, it's critical to implement these deliberate strategies in our daily lives to improve our health and lower our risk of developing numerous chronic disorders. Thus, begin living a healthy lifestyle today and never forget that even tiny adjustments can have a big impact on your overall well-being. Thus, take control of your health now to benefit from a future free of diabetes.

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DIETARY SUPPLEMENTATION OF VITAMIN E AND SELENIUM IN POULTRY

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Abstract
Vitamin E and selenium (Se) play critical roles in poultry nutrition, particularly due to their antioxidant properties, which help mitigate oxidative stress in birds. These micronutrients are essential for enhancing immunity, improving reproductive performance, and supporting growth in poultry. Selenium works synergistically with Vitamin E to protect cellular membranes and prevent tissue damage. This article reviews the roles, benefits, mechanisms, and recent studies on the dietary supplementation of Vitamin E and selenium in poultry production, while also addressing the challenges associated with their supplementation.

Keywords: Vitamin E, Selenium, Poultry, Antioxidants, Synergistic effects, Nutrition

Introduction

The poultry industry is continually striving to improve production efficiency, health, and overall performance of birds. Nutrition plays a pivotal role in achieving these goals, and the inclusion of micronutrients like Vitamin E and selenium has been shown to have substantial benefits for poultry. Both Vitamin E and selenium act as antioxidants, preventing oxidative damage caused by free radicals, which can be detrimental to poultry health and productivity.

Oxidative stress can result from several factors, including high metabolic rates, environmental stressors (e.g., heat, toxins), and diseases. The balance between oxidative stress and antioxidant defenses is crucial for maintaining health in poultry. This is where Vitamin E and selenium come into play, as both nutrients enhance the bird's antioxidant capacity, ensuring better immune function, growth, and overall performance.

Roles of Vitamin E and Selenium in Poultry Nutrition

Vitamin E

Vitamin E (α-tocopherol) is a fat-soluble antioxidant that protects cellular membranes from oxidative damage by scavenging free radicals. In poultry, it plays several roles:

1. **Antioxidant Protection**: Vitamin E acts as the first line of defense in lipid membranes against peroxidation, a process where free radicals damage fat cells. This protects tissue integrity, particularly in muscles and organs.
2. **Immune System Function**: Research shows that Vitamin E enhances both humoral (antibody-mediated) and cell-mediated immune responses in poultry. Studies by Sahin *et al.,*

(2022) demonstrated improved immune responses in chickens supplemented with Vitamin E.

3. **Growth and Performance**: Vitamin E has been associated with better feed conversion ratios, growth rates, and carcass quality. A study by Zhang *et al.,* (2023) found that Vitamin E supplementation improved weight gain and meat quality in broilers.
4. **Reproductive Health**: Vitamin E supports reproductive functions, particularly by enhancing egg quality and fertility. It prevents oxidative damage in sperm cells and reproductive tissues, ensuring better fertility rates in breeder hens.

Selenium

Selenium is an essential trace mineral that functions as a cofactor for the enzyme glutathione peroxidase (GSH-Px), a critical antioxidant enzyme that protects tissues from oxidative stress. Selenium's role in poultry includes:

1. **Antioxidant Defense**: Selenium's main role is to act as a cofactor in antioxidant enzymes like glutathione peroxidase, which neutralizes hydrogen peroxide and lipid peroxides, preventing oxidative damage to cells.
2. **Immune System Support**: Selenium enhances immune function by supporting white blood cell production and function, and recent studies have shown improved resistance to diseases in poultry with adequate selenium intake (Attia *et al.,*2023).
3. **Growth and Development**: Selenium also plays a role in thyroid hormone metabolism, which is essential for growth and development in poultry. Inadequate selenium levels can lead to stunted growth and poor performance.
4. **Muscle Health**: Selenium prevents the development of white muscle disease in poultry, a condition caused by oxidative damage to muscle tissues. Proper selenium levels ensure muscle integrity and overall physical performance.

Synergistic Effects of Vitamin E and Selenium

Vitamin E and selenium work synergistically to enhance the antioxidant defense mechanisms in poultry. While Vitamin E prevents lipid peroxidation at the membrane level, selenium-dependent enzymes like GSH-Px remove harmful peroxides from within the cells. This combined action effectively minimizes oxidative stress and supports cellular health.

Recent studies by Liu *et al.,* (2022) have shown that co-supplementation of Vitamin E and selenium leads to significantly improved growth performance, immune response, and meat quality in broilers. Their research found that the synergistic effect of these two nutrients provided more significant benefits compared to their individual supplementation, particularly under stress conditions.

Benefits of Vitamin E and Selenium Supplementation in Poultry

1. Improved Immunity and Disease Resistance

Vitamin E and selenium enhance the immune system by improving the function of macrophages, neutrophils, and lymphocytes. Vitamin E, in particular, boosts antibody production, while selenium enhances the ability of immune cells to kill pathogens.

A study by Surai *et al.,* (2021) demonstrated that broilers supplemented with both Vitamin E and selenium had a reduced incidence of diseases like coccidiosis and infectious bronchitis, compared to non-supplemented birds. The enhanced immunity allows poultry to better resist infections and recover more quickly from diseases.

2. Enhanced Growth and Feed Efficiency

Several studies have documented the positive effects of Vitamin E and selenium on growth performance. Birds supplemented with these nutrients typically have better feed conversion ratios (FCR), meaning they require less feed to gain weight. This is especially important in commercial poultry production, where feed costs represent a significant portion of total production costs.

In a trial conducted by Wang *et al.,* (2023), broilers fed a diet supplemented with Vitamin E and selenium showed a 10% improvement in weight gain and a 15% improvement in FCR compared to the control group.

3. Meat Quality Improvement

Supplementation with Vitamin E and selenium has been shown to improve meat quality by preventing lipid oxidation, which can negatively affect meat flavor, color, and shelf life. Poultry meat is particularly prone to oxidation due to its high unsaturated fat content.

A study by Blesbois *et al.,* (2023) reported that meat from chickens supplemented with Vitamin E and selenium had higher oxidative stability, meaning it stayed fresher for longer periods during storage.

4. Reproductive Performance

In breeding hens and roosters, Vitamin E and selenium support reproductive functions by preventing oxidative damage to sperm and egg cells. Birds supplemented with these nutrients tend to have better fertility rates, hatchability, and chick quality.

According to studies by Nasiri *et al.,* (2022), breeder hens supplemented with Vitamin E and selenium showed a 20% improvement in fertility rates and a 15% increase in hatchability.

Challenges in Supplementation

1. Optimal Dosage

Determining the optimal dosage of Vitamin E and selenium for different poultry species and production stages is a significant challenge. Excessive supplementation can lead to toxicity, while insufficient amounts may not provide the desired benefits. Careful management is required to ensure that dietary levels are appropriate for the specific needs of the flock.

2. Form of Selenium

Selenium can be provided in organic (selenium yeast) or inorganic forms (sodium selenite), with the organic form generally considered more bioavailable and less toxic at higher doses. However, it is also more expensive. Recent studies indicate that organic selenium may offer superior benefits in terms of absorption and efficacy compared to inorganic forms (Jiang *et al.,* 2023).

3. Cost

Both Vitamin E and selenium supplementation add to the cost of poultry diets. For smaller poultry operations, the cost of these supplements might be prohibitive. However, the long-term benefits in terms of growth, health, and reproductive performance can outweigh the initial cost.

Conclusion

Vitamin E and selenium are essential dietary supplements in poultry production, offering multiple benefits ranging from enhanced immune function and growth performance to improved reproductive health and meat quality. Their synergistic effects as antioxidants help reduce oxidative stress, which is critical for maintaining poultry health, especially under stressful environmental or

disease conditions. Despite challenges like determining the right dosage and form, the benefits of Vitamin E and selenium in poultry diets are well-documented and are likely to become even more important in the future as producers aim to improve production efficiency while maintaining animal health.

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REPETITIVE DNA - SIGNIFICANCE IN EVOLUTION

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Abstract
Repetitive DNA refers to DNA sequences repeated multiple times within the genome. Repetitive DNA can serve various functions and influence genome stability, gene regulation, and evolution. Some repetitive elements, like certain transposable elements, can contribute to genetic diversity and adaptability, while others may be involved in diseases or genetic disorders.

Introduction
The term "repetitive DNA" (repeats, DNA repeats, repetitive sequences) refers to DNA fragments present in multiple copies of the genome. Orgel and Crick (1980) termed these sequences "selfish DNA" because it arises when a DNA sequence spreads by forming additional copies within the genome and makes no specific contribution to the phenotype. Selfish DNA refers not only to repetitive sequences but also to certain other DNA that appear to have little or no function, such as much of the DNA in the introns of genes and parts of the DNA sequences between the genes.

Organization of repetitive sequences: In most genomes, repeated sequences comprise a large portion of the DNA content of the cells. For example, 95% of the onion genome is composed of repeated sequences and at least 50% or much more in humans.

Types of repetitive DNA sequences: Repetitive DNA elements can be divided into two major groups, distinguished by their genomic organization and chromosome localization, although intermediate forms of organization can exist too.

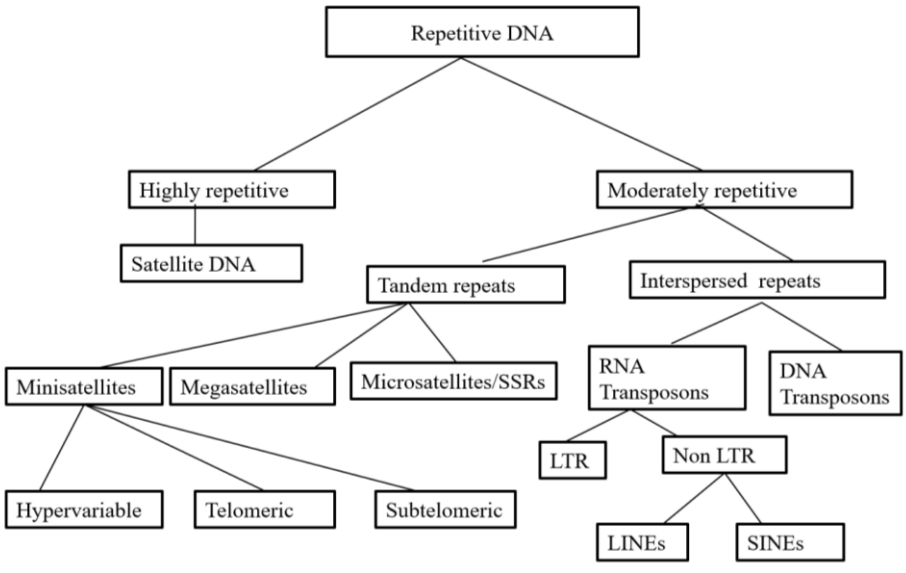

Fig. showing different repetitive DNA sequences

Highly repetitive sequences: These are short sequences (5 to 10 bp) amounting to 10% of the genome and repeated several times, usually occurring as tandem repeats (present in approximately 10^6 copies per haploid genome). Different non-repetitive sequences are not, however, inserted between them. Typically, every repeating unit's sequence is preserved. In this class, the majority of the sequences are found in the heterochromatin regions of the chromosomes; centromeres or telomeres. Meiosis and recombination chromosomal pairing are arranged by highly repetitive regions that interact with particular proteins.

Satellite DNA: These are represented by monomer sequences, usually less than 2000-bp long, tandemly reiterated up to 10^5 copies per haploid animal, and located in the pericentromeric and or telomeric heterochromatic regions. The percentage of satellite DNA in various organisms, such as prokaryotes, plants, and mammals, ranges from 1 to 65% of the total DNA.

Moderately or dispersed repetitive sequences: These include short (150 to 300-bp) sequences or long ones (5-kbp) amounting to about 40% and 1-2% of the total genome, respectively. Each haploid genome has 10^3-10^5 copies of these repetitive sequences, which are distributed across the euchromatin. These sequences have a role in controlling how genes are expressed. In some cases, long dispersed repeats of 300 to 600 bp show homology with the retroviruses. These include interspersed and tandem repeats.

Interspersed repetitive DNA: Interspersed repeat sequences scattered throughout the genome have arisen by transposition, having the “ability to jump from one place to another in the genome”. Transposable elements have been found in all organisms and were initially identified in maize.

RNA transposons: RNA transposons also known as retroelements or retrotransposons replicate by transcription of genomic copies followed by reverse transcription and ultimate integration of the cDNA copy back into the genome.

RNA transposons fall into two broad types based on their structural relationship:

2.1.1.1. LTR elements: LTR includes retroviruses whose genomes are made up of RNA. They infect different types of vertebrates. Retroviruses incorporated into vertebrate chromosomes that are passed down from generation to generation as a part of the host genome are known as endogenous retroviruses or EVRs. Some are still active and might directly synthesize the exogenous viruses at some stage in a cell's lifetime. However, the majority of them are decayed relics and no longer can form viruses.

Non LTR elements

LINEs (Long Interspersed Nuclear Elements) are several thousand base pairs in size and makeup about 17% of the total human genome. They contain reverse-transcriptase-like genes involved in the retrotransposition process. Many LINEs also code for an endonuclease (e.g. RNase H). The most abundant LINE family is the 7-kbp, L1 repeat element having >500,000 copies and accounts for approximately 15% of the human genome.

SINEs (Short Interspersed Nuclear Elements) are small elements, usually 100 to 500 bp in length, accounting for 11% of the human genome (Richard and Batzer 2009). SINEs do not have reverse transcriptase genes, instead, they borrow reverse transcriptase enzymes from other retroelements. A well-known example of SINE in the human genome is Alu sequences, which are 350 base pairs long, do not contain any coding sequences, and have over one million copies.

DNA Transposons: DNA transposable elements move to new locations within the host genome via exclusively DNA intermediates and do not require RNA intermediate. They code for a transposase responsible for integration and excision processes and are flanked by short terminal inverted repeats. During integration a short sequence of the host is duplicated, leading to direct repeats of 3-8 bp at each side of the transposon copy. The first transposon described in plants was the Ac-Ds control element of maize (*Zea mays* L.) discovered by Barbara McClintock.

Miniature inverted-repeat transposable elements (MITEs) are a superfamily of transposons that are characterized by small size (<500 bp), short TIRs, AT-richness, high levels of internal sequence divergence, the potential to form secondary structures, relatively large copy numbers (typically >1000 per haploid genome), and a preference for sequence-defined integration sites such as TA or TAA.

Tandem repeats: Individual copies are arranged adjacently to each other forming tandem arrays of the monomeric unit. Such tandemly repeated DNAs are found preferentially at specific positions of the chromosomes, such as the pericentromeric, sub-telomeric, telomeric, or intercalary regions. DNA elements arranged in tandem arrays include different types of satellite DNAs, the telomeric repeat, and the rDNA.

Mega satellite DNA: These are characterized by tandemly repeated DNA in which the repeat unit is approximately 50-400 times, producing blocks that can be hundreds of kilobases long. Some mega satellites are composed of coding repeats.

Minisatellite DNA: This comprises tandem copies of repeats that are 6-100 nucleotides in length also called a variable number of tandem repeats (VNTR). The majority of the minisatellites are GC-rich, with a strong strand asymmetry. The nuclear genome has hundreds of locations where minisatellites are found, often forming families of linked sequences. A gain or deletion of one or more repeat units is typically observed in minisatellite mutations. A thousand times higher frequency of such mutations occurs at hypervariable minisatellite loci than in genes encoding proteins. Unlike microsatellites, which usually alter during the DNA synthesis stage of the mitotic cell cycle, minisatellites alter during meiosis, changing overall length and repeat composition. Minisatellite tracts have proven very useful for genomic mapping and linkage studies.

Telomeric repeats: These are composed of multiple repeats of short sequence elements (typically 5 to 8 bp in length, with a GT-rich strand oriented 5' to 3' toward the end of the chromosome) and range in length from a few repeat units to >10-kbp. The three-dimensional nuclear network of poorly transcribed areas formed by long simple sequence tandem repeats of interstitial TTAGGG arrays involves relocating gene silencing.

Sub-telomeric repeats: Sub-telomeric repeats are the classes of repetitive sequences that are interspersed within the last 500,000 bases of non-repetitive DNA located adjacent to the telomere.

Microsatellite/Simple Sequence Repeats (SSRs): Tandem repeats are made up of usually, di-, tri-, or tetranucleotide units (1-6 bps), and were earlier called simple sequences. Later, this class of DNA was coined as microsatellites by Tautz in 1989. Simple sequence repeats (SSRs), often known as microsatellites, are widely distributed across the coding and non-coding sections of the genomes of eukaryotic and prokaryotic organisms. Some microsatellites occurring in flanking regions of coding sequences are believed to play significant roles in the regulation of gene expression by forming

various DNA secondary structures and offering a mechanism of unwinding. These elements containing identical motifs may be found at many thousand genomic loci.

Evolution and Inter-species Variation of Repeat Sequences

Britten and Kohne (1968) suggested that a segment undergoes manifold replication; the copies are integrated into the chromosomes; these become associated with a favourable genetic element and are disseminated through the species by natural selection Tautz (1989) proposed several mechanisms for their evolution, such as stand slippage during replication, base misalignment, and unequal cross-over between homologous chromosomes during meiosis, sister chromatid exchanges or even insertion of the viral genome.

Functional significance of repetitive sequences

Major constituents of centromeric heterochromatin are repetitive DNA sequences. Numerous plant species have had repetitive DNA segments, mostly or only found in the centromeric region, cloned. However, every piece that has been reported is distinct to a particular species or genome. In the same species or species with homologous genomes, some of them are absent from all of the chromosomes. It has been demonstrated in recent research that repetitive elements affect the host genomes' chromosomal structure, function, and evolution. They are highly appealing study subjects due to their connections to the promoters and coding sections of the genes. The modifications to the tracts have been observed to progressively impact transcription, mRNA processing, translation, folding, stability, and aggregation rates, in addition to gross morphology.

Repetitive sequences as molecular marker: Advantages of using these sequences as molecular markers: (i) short tandem repetitive (STR) sequences are evenly distributed all over the genome (ii), are often conserved between closely related species (iii) and are co-dominant.

Minisatellites as Molecular Markers: Two techniques prevail.

In one method, minisatellite-complementary probes are hybridized to restriction-digested genomic DNA to produce highly variable restriction fragment length polymorphism (RFLP) fingerprints. Alternatively, minisatellites are used as single primers in a polymerase chain reaction (PCR; e.g., in direct amplification of minisatellite DNA [DAMD]. Gustafson and colleagues were the first to apply minisatellite-primed PCR to plants. In an approach coined **direct amplification of minisatellite DNA (DAMD)-PCR**, they amplified genomic DNA of various, mainly diploid *Triticum* species under high-stringency conditions, using known plant and animal minisatellite core sequences as single primers.

Microsatellites as Molecular Markers: Numerous methods have been developed that exploit microsatellites as molecular markers, in one way or the other. The most important variant is the locus-specific PCR amplification of nuclear and organellar microsatellites with flanking primers. Other methods use microsatellite motifs (instead of flanking regions) as single PCR primers, as PCR primers in combination with other primer types, or as hybridization probes.

Transposons as Molecular Markers

Repetitive DNAs have been extensively applied as physical chromosome markers in comparative studies, identification of chromosome rearrangements and sex chromosomes, chromosome evolution analysis, and applied genetics. Retrotransposons are advantageous as molecular markers because they are ubiquitous in the plant kingdom and are normally present in high copy numbers as interspersed repetitive sequences in plant genomes.

Conclusion

In summary, repetitive DNA is a valuable component of crop genomics and breeding. Its study helps in understanding genetic diversity, improving breeding efficiency, and developing crops with enhanced traits for agriculture.

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HARNESSING SEED ENDOPHYTES FOR SUSTAINABLE AGRICULTURE: PROMOTING PLANT RESILIENCE AND REDUCING PATHOGEN PRESSURE

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Abstract

Endophytes are microorganisms, including bacteria and fungi, that inhabit healthy plant tissue without causing symptoms. They can be transmitted from parent plants to their offspring, ensuring their presence in successive generations. These endophytes play a crucial role in promoting plant growth and health by weakening the strength of microbial pathogens. Seed endophytes are widely distributed and establish complex interactions with their host plants, ranging from mutualistic to antagonistic relationships. They colonize seeds internally and persist without causing any harm. The seed serves as both a reservoir and carrier of the microbial community, functioning as the endpoint for community assembly within the seed and the starting point for community assembly in seedlings. Seed endophytes can influence the expression of plant genes, leading to the development of desirable traits in crops such as resistance to adverse conditions. By harnessing the potential of seed endophytes, sustainable agricultural practices can be promoted.

Introduction

Seed endophytes exhibit transgenerational transfer, allowing for the direct transmission of endophytes from parent plants to their offspring. This ensures that seed endophytes are present in successive generations of seedlings. They weaken strength of microbial pathogens and aids in successful plant growth (Cope-Selby *et al*., 2017). Endophytes are microorganisms, either bacteria or fungi that inhabit the intercellular or intracellular spaces of healthy plant tissues, without causing any noticeable disease symptoms. They are widely distributed, found in various plant species, and have been discovered in almost all plants studied thus far. The nature of their association with the host plants can be either obligate or facultative, and they do not pose any harm to their host plants. These endophytes engage in intricate interactions with their hosts, encompassing mutualistic and antagonistic relationships. The concept of seed-borne endophytes was initially introduced by Baker and Smith in 1966.Seed-vectored endophytes colonize plant seeds internally and persist without causing any disease symptoms. Seed endophytes serve as the endpoint for community assembly within the seed and also as a starting point for community assembly in the seedlings. In addition to carrying genetic information for the next generation, a seed also functions as a reservoir and carrier of a microbial community (Shahzad *et al*., 2018).

Mode of entry and establishment of seed endophyte in plants

Seed endophytic microbes associated with plants are primarily found in the rhizosphereor leaf surfaces. They have the capability to enter the plant tissues intercellularly or intracellularly, forming what is known as the "endosphere" (White *et al*., 2014). Plants release root exudates containing

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sugars, amino acids, organic acids, and vitamins which stimulate the growth of microbes present on or within seeds. Additionally, microbes from the surrounding soil can be recruited. The mobility of these microbes in the rhizosphere, facilitated by mycelial growth in fungi or flagellar motility in bacteria, allows them to access nutrient sources that may be inaccessible to plants alone. The main mechanisms by which seed endophytes enter and establish themselves include the production of root exudates that promote the adhesion and penetration of endophytic bacteria into the roots, utilization of cell wall degrading enzymes to enter the plant, and the presence of flagella and chemotaxis-induced motility.

Transmission of seed endophyte

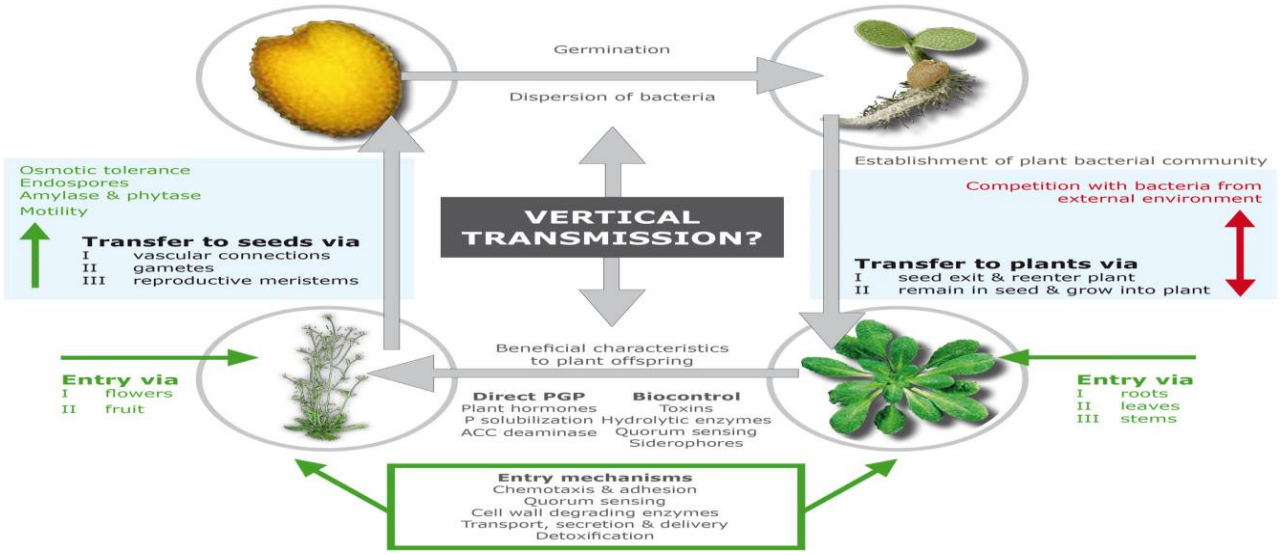

Fig 1: Different mode of transmission and colonization of Bacterial seed endophytes in plants (Truyens *et al.,* 2015)

Applications of seed endophyte

Seed endophytes possess significant potential for diverse applications in agriculture and industries related to plants (Li *et al*., 2019). Here are some of the potential uses:

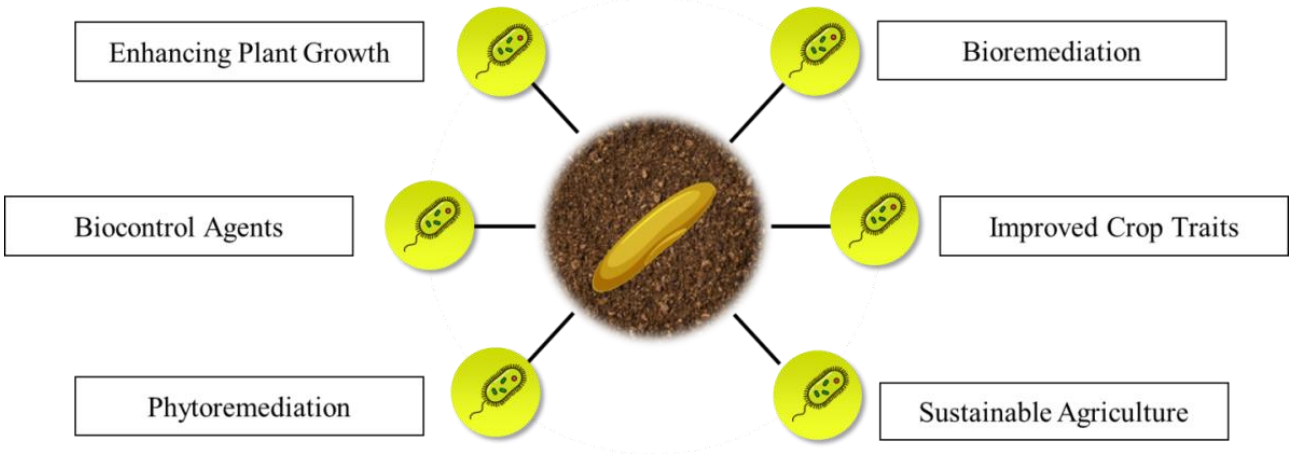

Fig 2: Role of seed Endophyte in plants

1. **Enhancing Plant Growth**: Seed endophytes have the ability to improve plant growth and development by facilitating nutrient absorption, enhancing stress tolerance, and promoting hormone production. This can result in higher crop yields and overall plant well-being.
2. **Biocontrol Agents**: Certain seed endophytes exhibit biocontrol properties, actively suppressing the growth and activity of plant pathogens. They can produce antimicrobial compounds or induce systemic resistance, offering a natural and sustainable approach to managing pests and diseases.
3. **Phytoremediation**: Seed endophytes can assist in phytoremediation processes by breaking down or detoxifying pollutants present in the soil. They can effectively degrade various contaminants, including heavy metals and organic pollutants, thereby aiding in the restoration of contaminated environments.
4. **Bioremediation**: Some seed endophytes possess the capability to metabolize or degrade harmful substances like pesticides or industrial pollutants. They contribute to the remediation of polluted sites, playing a crucial role in environmental restoration efforts.
5. **Improved Crop Traits**: Seed endophytes can influence the expression of plant genes, leading to the development of beneficial traits in crops. They can enhance characteristics such as drought tolerance, nutrient utilization efficiency, and resistance to adverse environmental conditions, facilitating the creation of improved crop varieties.
6. **Sustainable Agriculture**: By utilizing seed endophytes, it is possible to promote sustainable agricultural practices by reducing reliance on synthetic fertilizers, pesticides, and other chemical inputs. This approach offers a natural and environmentally friendly means of enhancing plant health and productivity while minimizing negative environmental impacts.

Conclusion

Exploration and harnessing of the potential of seed endophytes have the capacity to revolutionize agriculture and contribute to the development of sustainable and eco-friendly crop production systems. Ongoing research and application advancements in this field hold promise for addressing various challenges faced by modern agriculture while promoting sustainable practices.

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STRATEGIES TO MITIGATE METHANE EMISSIONS IN RICE CULTIVATION

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Abstract
Methane (CH_4) is a potent greenhouse gas with a global warming potential significantly greater than that of carbon dioxide (CO_2) over a short time frame. Methane is over 25 times more effective than CO_2 at trapping heat in the atmosphere over a 100-year period. Over a 20-year period, its impact is even more pronounced, being about 84 times more potent. While methane has a shorter atmospheric lifespan of about 12 years when compared to CO_2 and its immediate warming effects make it a critical target for climate mitigation efforts. It is responsible for a considerable portion of anthropogenic climate change, and its emissions from the agricultural sector are a key concern. This contemporary study focussed on uncovering the information related to several factors that influence methane emissions, specially rice cropping system and demonstrated suitable strategies to mitigate these emissions.

Introduction
India emitted approximately 34.5 million metric tons of methane in 2019, making it the third-largest emitter after China and the United States. India has the potential to cut 18% of its annual greenhouse gas emissions from agriculture and livestock, reports a team of researchers from the International Maize and Wheat Improvement Centre in the United Kingdom. The reduction potential represents 85.5 megatonnes of CO2 equivalent per year. And half of this is equivalent to the emissions from 30 million cars in a year (at 10,000 km per car annually) could be achieved by implementing just three measures at no cost: efficient use of fertiliser, adoption of zero-tillage and management of water used in rice irrigation. Enteric fermentation in cattle and other livestock accounts for nearly 27% of India's total methane emissions, emphasizing the impact of animal husbandry practices. Rice paddies alone contribute approximately 12.5 million metric tons annually.

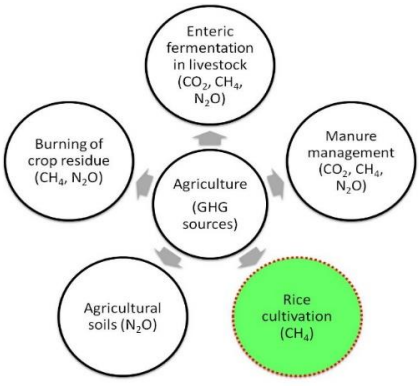

Fig:1. Sources of Methane Emissions in Agriculture

a) **Enteric Fermentation**: This is one of the largest sources of methane emissions in agriculture, accounting for about 40% of total agricultural methane emissions. Ruminant animals, such as cows, sheep, and goats, produce methane during digestion through a process called enteric fermentation. Microbes in the stomach break down food, releasing methane as a byproduct.
b) **Manure Management**: Manure management contributes approximately 20-25% of agricultural methane emissions. When animal waste is stored or treated in anaerobic conditions (without oxygen), it produces methane. This can occur in lagoons, pits, or when manure is spread on fields.

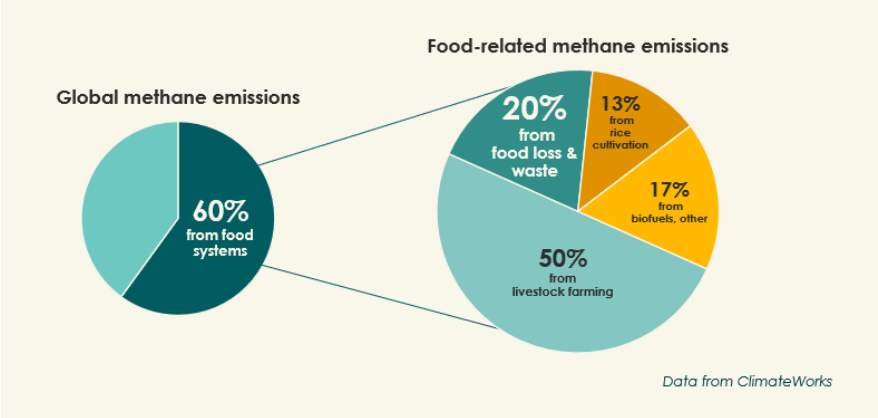

Fig:2. Global methane emissions

Rice cultivation accounts for about 10-12% of global agricultural methane emissions. Study conducted by Roth *et al.* (2020) suggested that rather than burning rice straw, incorporating it into the soil can enhance soil health and microbial activity, thereby reducing methane emissions.

Within the agricultural sector, rice account for about 30-40 per cent of agricultural methane emissions, making it one of the largest sources after livestock. Paddy fields are flooded to grow rice, creating anaerobic conditions that promote methane-producing bacteria in the soil. These bacteria break down organic matter and release methane. Methane emissions from rice cultivation primarily occur due to the anaerobic conditions created in flooded rice paddies. Study conducted by Kumar *et al.* (2018) uncovered from the study that focusing specifically on the AWD method is effective in reducing methane emissions while maintaining rice yield, also the study concluded the dual benefits of AWD i.e., decreased methane emissions and enhanced water conservation.

Anaerobic Decomposition: Rice fields are typically flooded to a certain depth to provide the water needed for rice growth. This flooding creates anaerobic (oxygen-poor) conditions in the soil. Under anaerobic conditions, certain bacteria thrive, particularly methanogens, which are microorganisms that produce methane as a metabolic byproduct when breaking down organic matter (plant residues, root exudates, etc.).

Organic Matter Breakdown: The organic matter in flooded rice fields comes from decaying plant material, soil organic matter, and root exudates released by the rice plants themselves. In anaerobic conditions, the breakdown of this organic matter by methanogenic bacteria leads to the production of methane gas. The process typically involves:

i. Fermentation of organic materials into simpler compounds.
ii. Conversion of these compounds into methane by methanogens.

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Waste Management: Agricultural waste management (e.g., crop residues) contributes a smaller percentage but is still relevant. The decomposition of organic waste in landfills and composting facilities can also produce methane, although this is often considered separately from agricultural emissions.

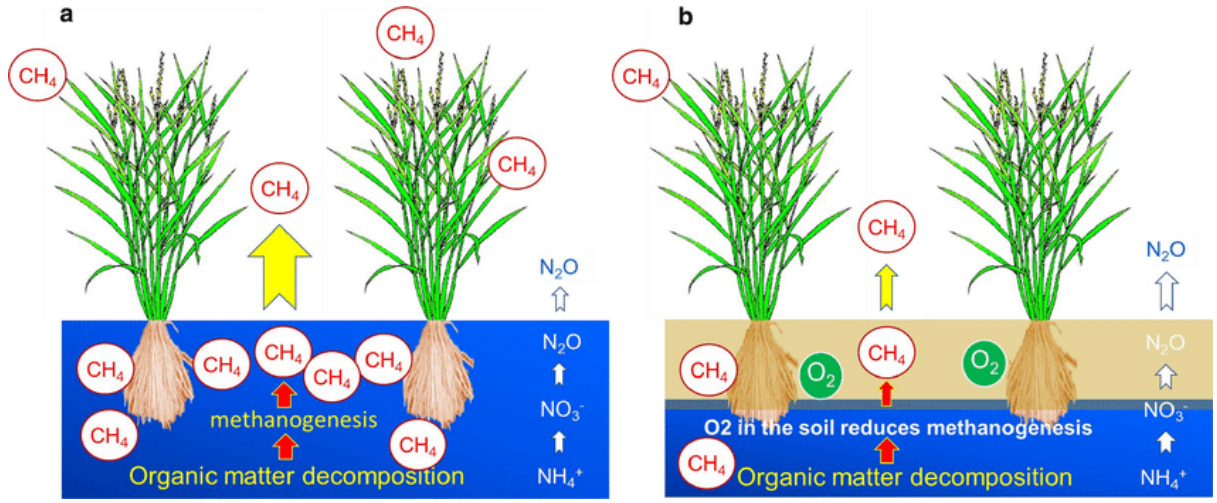

Fig:3. Methane Emissions in Rice due to Organic matter decomposition

3. Several factors can influence the amount of methane produced in rice fields

a) **Water Management**: Continuous flooding increases methane production, while practices like alternate wetting and drying (AWD) can significantly reduce emissions by promoting aerobic conditions.
b) **Soil Type**: Soil texture and composition affect microbial activity and organic matter decomposition rates. Soils with high clay content may retain water longer, leading to more methane production.
c) **Temperature**: Warmer temperatures can enhance microbial activity and increase methane production.
d) **Rice Variety**: Different rice varieties may influence methane emissions due to variations in root exudation and growth patterns.
e) **Nutrient Management**: The type and amount of fertilizers used can affect methane emissions. For instance, high nitrogen input can lead to increased organic matter decomposition.

4. Mitigation Strategies:

a) **Alternate Wetting and Drying (AWD)**: This irrigation practice involves allowing the field to dry intermittently, creating aerobic conditions that reduce methane production. Study conducted by Liu *et al.*, (2016) mentioned practices like Alternate Wetting and Drying (AWD) not only reduce methane emissions but can also enhance water efficiency.
b) **Crop Residue Management**: Incorporating or properly managing rice straw can limit anaerobic conditions and promote aerobic decomposition.

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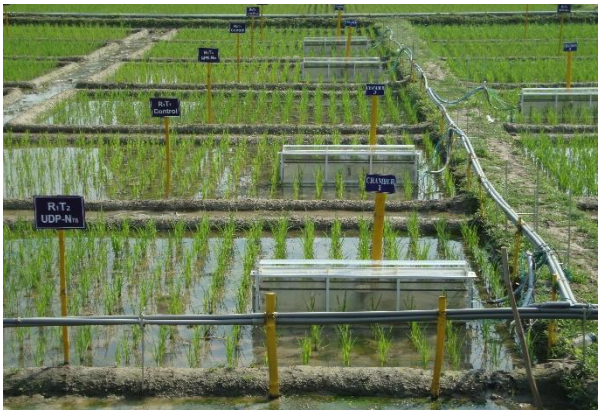

Fig:4 Alternate Wetting and Drying (AWD) in Paddy

Fig:5. Crop residue management

c) **Use of Cover Crops**: Planting cover crops in the dry season can enhance soil health and reduce methane emissions in the subsequent rice-growing season.
d) **Optimized Fertilizer Application**: Applying fertilizers more efficiently can reduce organic matter breakdown processes that lead to methane production.

Conclusion

Methane emissions from rice cultivation represent a significant environmental challenge, contributing to global warming and impacting air quality. Effective management practices, such as water-saving techniques, alternative wetting and drying, and improved rice varieties, can help mitigate these emissions. Additionally, integrating sustainable agricultural practices and promoting awareness among farmers are crucial for reducing methane outputs. By prioritizing these strategies, we can work towards a more sustainable rice production system that balances food security with environmental health. Continued research and collaboration among stakeholders will be essential in addressing this pressing issue.

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GLOBAL DIABETES EPIDEMIC: A GROWING CRISIS AFFECTING MILLIONS

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Diabetes is a long-lasting health condition that affects how your body turns food into energy, causing high levels of sugar in the blood. Over time, this can lead to serious problems with the heart, blood vessels, eyes, kidneys, and nerves. The most common type is type 2 diabetes, which usually happens in adults. It occurs when the body do not use insulin properly or doesn't make enough insulin. In the last 30 years, the number of people with type 2 diabetes has increased significantly in both developed and developing countries.

Type 1 diabetes is a condition that often starts in childhood, where the body does not produce any insulin on its own. This type is also known as juvenile diabetes or insulin-dependent diabetes. For people with diabetes, it's essential to have access to affordable treatments, especially insulin, to manage their condition and stay healthy.

Gestational diabetes is another type of diabetes that can develop during pregnancy. It means that your blood sugar levels become too high, even if you not have diabetes before. This condition usually goes away after the baby is born, but it needs to be managed carefully during pregnancy to keep both the mother and baby healthy. Women who have gestational diabetes are at higher risk of developing type 2 diabetes after child birth.

Diabetes is a significant global health concern, with its prevalence rising sharply over the past few decades. As of the latest data:

Global Prevalence:

- **Estimated Numbers**: As of 2021, approximately 537 million adults (20-79 years) were living with diabetes globally. This number is projected to rise to 643 million by 2030 and 783 million by 2045 if current trends continue.
- **Type 1 Diabetes**: This is less common, typically diagnosed in childhood, accounting for about 5-10% of all diabetes cases.
- **Type 2 Diabetes**: The most common form of diabetes, it makes about 90-95% of all diabetes cases.

Regional Prevalence: 9 (According to location of countries)

- **Western Pacific Region**: The region with the highest number of people with diabetes, including countries like China, which has one of the highest national burdens.
- **Southeast Asia and Africa**: These regions are experiencing the fastest growth in diabetes prevalence due to rapid urbanization, changes in lifestyle, and dietary habits.
- **North America and Europe**: Have high prevalence rates, driven by high obesity rates and aging populations.

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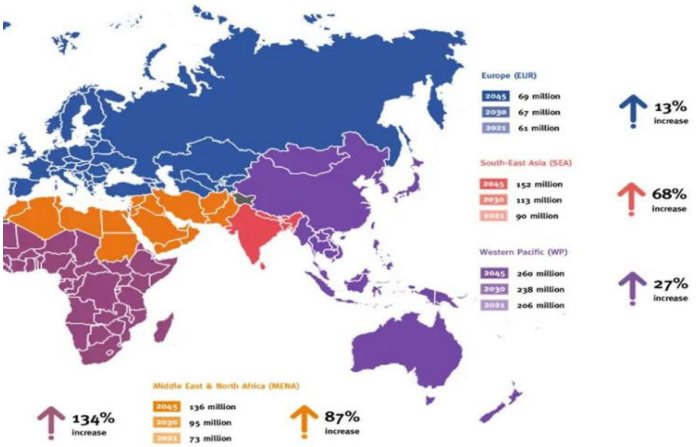
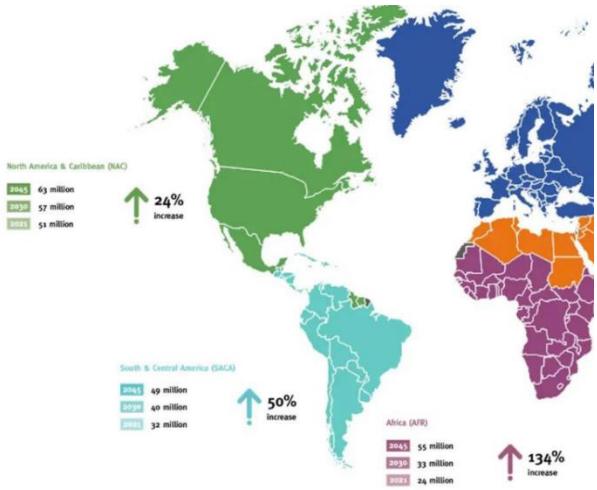
Worldwide Prevalence on Diabetes

In year 2024, diabetes affects over 540 million adults globally, which is about (10.5%) of the adult population. This number is expected to rise significantly, with projections indicating that by 2045, around 783 million adults, or (12.2%) of the global population, will be living with diabetes. The majority of these cases, over 90%, are type 2 diabetes.



According to (Diet Atlas), The global burden of diabetes is similar, not only in terms of health but also in economic costs. In 2021 alone, diabetes accounted for approximately 966 billion (US dollars) in global health cost. Additionally, diabetes-related complications lead to increased mortality, with 6.7 million deaths happen by the disease in the same year. Around 541 million adults have Impaired Glucose Tolerance (when your body has trouble in processing sugar properly. It means your blood sugar levels are higher than normal but not high enough to be considered diabetes), which places them at high risk of type 2 diabetes.



As shown above in the picture it shows about the cases of diabetes (in year 2021) and future prediction about increase in diabetes cases (in year 2045) across the world. By 2045, data shows that 1 in 8 adults, approximately 783 million, will be living with diabetes, a total increase of (46%).

Regions	2021	2045	Increased up to
North America	51 million	63 million	24%
South America	32 million	49 million	50%
Africa	24 million	55 million	134%
North Africa	73 million	136 million	87%
Western Pacific	206 million	260 million	275%
India	90 million	152 million	68%
Europe	61 million	69 million	13%

Contribution factors for diabetes

A person is at high risk of diabetes if one has-

Family history, unhealthy diet, physical inactivity, obesity, older age, high blood pressure, high cholesterol, shift from rural to urbanisation, stress and depression, high alcohol and smoking habits.

Impact of diabetes on economic status of a country-

The impact of diabetes on a country's healthcare system is profound, affecting not only the individuals diagnosed with the condition but also the broader economic and healthcare infrastructure. Here are some key points to consider:

1. Increased Healthcare Costs: Diabetes management is expensive due to the need for continuous medication, regular monitoring, and treatment of complications.
2. Burden on Healthcare Infrastructure: Diabetes requires regular healthcare services, including physician visits, lab tests, and hospitalizations. This increases the workload on healthcare facilities and professionals.
3. Complications and Comorbidities: Diabetes often leads to severe complications such as cardiovascular disease, stroke and kidney failure. These complications necessitate more complex and costly treatments, further burdening the healthcare system.
4. Public Health Interventions: Governments may need to invest in public health initiatives to prevent diabetes, including awareness campaigns, lifestyle interventions, and early detection programs.
5. Insurance and Access to Care: In countries with insurance-based healthcare systems, diabetes can lead to higher premiums and out-of-pocket expenses, affecting access to necessary care, especially for low-income individuals.
6. Long-Term Economic Impact: Over time, the economic impact of diabetes can be substantial due to the cumulative costs of care, loss of productivity, and increased disability rates. This can lead to greater economic inequality and strain on social services.

Addressing the impact of diabetes on a country’s healthcare system requires a multifaceted approach, including prevention, early detection, effective management, and policy interventions aimed at reducing the overall burden of the disease.

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IMMUNE PROPERTIES OF SEAWEEDS

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Introduction

Seaweeds, especially macroalgae, play an important role in marine ecosystems by providing food and habitat for various marine species, including fish. Though seaweeds themselves do not possess immune systems akin to animals, they can influence fish immune responses in several ways. The relationship between seaweeds and fish immunity involves both direct and indirect mechanisms. Below are the main ways in which seaweeds impact fish immune responses:

Nutritional Benefits

Seaweeds are rich in bioactive compounds, such as vitamins, minerals (iodine, zinc, etc.), polysaccharides (e.g., alginates, carrageenan, and agar), and antioxidants, which can enhance the immune function of fish:

- **Polysaccharides**: These compounds can act as immunostimulants, enhancing fish immune cells (e.g., macrophages, lymphocytes).
- **Antioxidants**: The antioxidants in seaweeds help neutralize free radicals, reducing oxidative stress, and supporting the overall immune response in fish.
- **Amino Acids**: Seaweeds provide essential amino acids, which are vital for the synthesis of proteins, including those involved in immune function.

Immunostimulatory Compounds

Seaweeds contain several bioactive molecules with immunostimulatory effects. These compounds enhance the innate immune responses of fish:

- **β-glucans**: These polysaccharides found in seaweeds stimulate the immune system by activating macrophages, neutrophils, and other components of the innate immune response.
- **Lectins**: Lectins in seaweeds can bind to specific carbohydrate structures on pathogens, helping the fish immune system recognize and fight infections.
- **Sulfated polysaccharides**: These compounds have antiviral and antimicrobial properties, helping fish resist pathogens and diseases.

Antimicrobial and Antiviral Properties

Certain seaweeds have antimicrobial and antiviral activities that can protect fish from various pathogens:

- **Antibacterial effects**: Seaweed extracts, such as those from *Ulva* and *Sargassum* species, have been shown to inhibit bacterial growth, thus reducing the risk of bacterial infections in fish.

- **Antiviral effects**: Some seaweed polysaccharides, such as carrageenan, are known for their antiviral properties, which can help fish combat viral pathogens.

Prebiotic Effects

Seaweeds can act as prebiotics, supporting the growth of beneficial gut microbes in fish. A healthy gut microbiome is crucial for immune system function:

- **Enhancing gut flora**: Seaweed-based diets can promote the growth of beneficial bacteria in the fish's digestive tract, which in turn can improve the immune response.
- **Gut health**: A well-balanced gut microbiota improves nutrient absorption, reduces inflammation, and enhances the fish's ability to resist infections.

Stress Reduction

By reducing environmental stressors such as water pollution or pathogenic outbreaks, seaweed farming can help mitigate stress in fish. Lower stress levels are associated with stronger immune responses, as chronic stress can suppress immune function:

- **Water filtration**: Seaweeds help improve water quality by absorbing excess nutrients and pollutants, which can reduce stress and improve overall fish health.
- **Habitat protection**: Seaweeds provide shelter and habitat for fish, reducing their exposure to predators and environmental stress, which indirectly boosts their immune response.

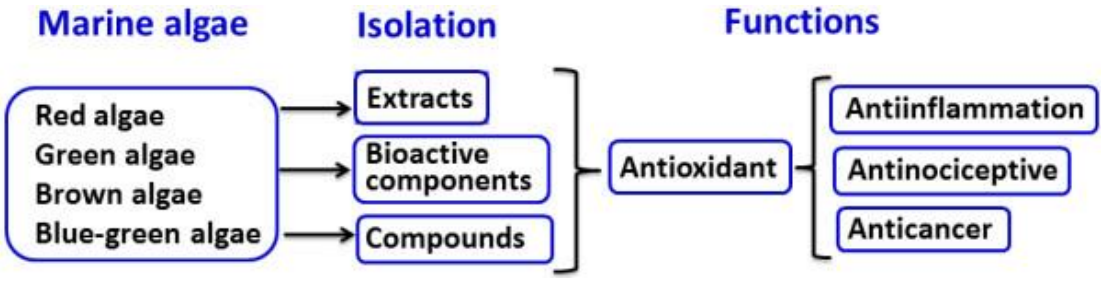
Seaweed-Derived Functional Feeds

Seaweed extracts and powders are often used as additives in aquaculture feeds, as they are known to enhance fish health and immunity:

- **Growth performance**: Seaweed-enriched diets have been shown to improve growth rates in fish, often leading to more robust immune responses.
- **Disease resistance**: Fish fed with seaweed supplements tend to show improved resistance to common pathogens, including bacterial and viral diseases.

For their various bioactivities, biomaterials derived from marine algae are important ingredients in many products, such as cosmetics and drugs for treating cancer and other diseases. The anti-oxidative effects and bioactivities of several different crude extracts of algae have been evaluated both *in vitro a*nd *in vivo*.

Marine algal natural products with anti-oxidative, anti-inflammatory, anti-nociceptive, and anti-cancer properties.



Antioxidant activities and bioactive components of marine algae extracts

Antioxidant activities have been identified in various marine algae, including red, green, and brown algae species, and in their enzymatic extracts. Ethanol extracts of the *Callophyllis japonica* (Kang *et al.,* 2005) and *Gracilaria tenuistipitata* species of red algae reportedly have antioxidant effects.

Anti-inflammatory and antinociceptive properties of marine algae extracts and components

Oxidative stress plays important roles in endothelial dysfunction, lung disease, gastrointestinal dysfunction, and atherosclerosis, all of which involve inflammatory reactions. Many marine natural products that contain antioxidants are known to have anti-inflammatory effects.The anti-inflammatory effects of a methanol extract of *Neorhodomela aculeata* in neurological diseases included inhibiting cellular reactive oxygen species (ROS) generation, H_2O_2-induced lipid peroxidation, and inducible nitric oxide synthase (Lim *et al.*,,,2006) *Dunaliella bardawil* is rich in antioxidant beta-carotene.

Anti-cancer effects of marine algae extracts and components

Among green algae, a hot water extract of *Capsosiphon fulvescens* that contained polysaccharides induced the apoptosis of gastric cancer cells [Park *et al.*,,,2006] via the PI3K/Akt pathway. Studies of brown algae have shown that glycoproteins from *Laminaria japonica*and fucoidans from *Sargassum hornery*, *Eclonia cava*, and *Costaria costata* (Ermakova *et al.,* 2011) had anti-cancer effects on human colon cancer cells.

Conclusion

The immune responses of fish can be positively influenced by seaweeds through nutritional supplementation, prebiotic support, and exposure to bioactive compounds with antimicrobial properties. Seaweeds are therefore a valuable component in enhancing the health and immunity of fish, particularly in aquaculture environments.

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STRATEGIES OF SURVIVAL AGAINST ENEMIES IN INSECTS

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Abstract
Insects exhibit a wide range of defense mechanisms, allowing them to survive in diverse and hostile environments. These defenses can be classified into three main categories: behavioral, morphological and chemical. Behavioral strategies include rapid escape, flight, feigning death, and group defense, while morphological adaptations like exoskeletons, spines and camouflage offer physical protection. Chemical defenses involve venom, defensive secretions and toxic compounds, which can repel or incapacitate predators. Mimicry and alarm signals enhance these protective tactics, with some species mimicking harmful organisms or releasing warning pheromones to communicate danger. These intricate adaptations not only defend against predators but also protect from environmental threats and parasitism, making insects a remarkably resilient group of organisms.

Introduction

Arthropods and insects, the largest groups of organisms by species numbers and biomass, (Stork and Blackburn, 1993). While some humans consume insects, many Western cultures avoid them. However, insects are a vital food source for numerous organisms, being nutritious, abundant, and diverse (Patel *et al*., 2019). Insectivores rely heavily on them, while omnivores and herbivores may consume them opportunistically or inadvertently.

Insect defense mechanisms include rapid escape, such as running or flying, like cockroaches and house flies which quickly respond to threats. Some insects, like pill bugs, play dead (thanatosis) or drop from their substrate when threatened (War *et al*., 2012; Bhuva *et al*., 2024). These defense strategies help insects protect themselves from predators, parasites, and environmental threats.

Types of insect defense	(1) Behavioral defense
	(2) Morphological defense
	(3) Chemical defense

1. Behavioral defense

Behavioral defenses in insects encompass a wide range of strategies and adaptations that help them avoid or deter enemies or predators. These behaviors can enhance survival by reducing the chances of detection, increasing escape opportunities, or intimidating potential threats (War *et al*., 2012). Here are some examples of behavioral defenses in insects:

a) Escape behaviors: Insects may exhibit specific escape behaviors when faced with a threat. These behaviors can include rapid running or jumping, playing dead, or engaging in erratic movements/hiding to confuse predators. For example, rolling into a protective ball (pill bugs). Some caterpillars encase themselves in a folded leaf or other hiding place (rice leaf folder).

b) Thanatosis: Many insects feign dead which is a form of defense against a predator by playing like dead.

c) Flight: Many insects can fly, which allows them to quickly escape from predators. Flight enables them to evade capture by moving to safer locations or simply staying out of reach.

d) Defensive postures: Insects can adopt defensive postures to make themselves appear larger or more intimidating. This may involve spreading out their wings, extending spines or hairs, or assuming a specific body posture to deter predators (Hawk moth larvae). Caterpillars often drop from their food on a strand of silk when disturbed and reel themselves back up when the danger has passed (Reflex dropping).

e) Alarm signals: Some insects display warning colors or patterns to signal their unpalatability or toxicity, deterring potential predators. Social insects, such as honey bees and ants, have alarm pheromones or acoustic signals that can be used to alert their colony members to the presence of a predator. This helps mobilize a collective defense response and increases the chances of survival.

f) Group defense: Insects that live in groups or colonies often display collective defense behaviors. This can involve coordinated actions, such as swarming, stinging, or releasing chemical deterrents, to repel predators and protect the group.

2. Morphological Defenses:

Morphological defenses in insects refer to the physical structures and adaptations that protect predators, parasites, or environmental threats. These morphological features can deter or hinder potential attackers, enhance camouflage, or provide physical barriers (War *et al*., 2012). Here are some examples of morphological defenses in insects:

a) Exoskeleton: Insects possess a rigid external covering called the exoskeleton, which is protective armor. The exoskeleton is composed of a tough substance called chitin, providing physical defense against predators and environmental hazards. Hard & highly sclerotized, it can resist break and penetration by insectivore birds - Jewel beetle, rhinoceros beetle.

b) Spines, spurs & thorns: Some insects have evolved specialized structures such as spines, spurs, or thorns on their bodies, wings, or legs. These sharp projections can deter or injure predators that attempt to attack or handle them.

c) Protective coloration: Insects often have color patterns and body shapes that help them blend into their environment, making it difficult for predators to spot them. Cryptic coloration provides camouflage and makes it difficult for predators to detect.

d) Mimicry: Certain insects mimic the appearance of harmful or toxic species, gaining protection by appearing dangerous to predators.

e) Batesian mimicry: Insects may mimic the appearance of toxic or venomous species to deceive predators into perceiving them as harmful. By resembling a noxious model species, the mimic gains protection from predators that have learned to avoid the model.

f) Armor-like structures: Some insects have evolved hard, shell-like structures or thickened cuticles that provide physical protection. Examples include beetles with tough elytra (forewings) and beetles or bugs with thickened exoskeletons. *E.g*., Sclerotized cerci in Earwigs, Raptorial leg in Preying mantids and Tentacles in Danaidae larvae. Some caterpillars have eyespots that make them look like bigger, more dangerous animals, like a snake.

3. Chemical defense

Chemical defense in insects refers to the use of specialized compounds produced by insects as a means of defense against predators, parasites, or competitors (War *et al*., 2012). These chemical defenses can serve various purposes, such as deterring attackers, incapacitating or repelling predators, or even communicating warnings to conspecifics. Here are some of the chemical defense mechanisms in insects:

a) Venomous stings or bites: Some insects, such as bees, wasps, ants, and certain beetles, possess venom glands and specialized stingers or mouthparts that allow them to inject venom into predators. Venoms can contain a variety of components, such as enzymes, peptides, or alkaloids, which can immobilize or incapacitate predators, providing the insect with an opportunity to escape.

b) Defensive secretions: Some insects produce defensive secretions that are released when they are threatened or attacked. These secretions can be toxic, malodorous, irritating, or sticky, acting as a deterrent to predators. Examples include defensive secretions produced by bombardier beetles that release noxious and hot chemical sprays or stink bugs that emit foul-smelling compounds.

c) Chemical repellents: Insects may produce compounds that have repelling properties, deterring predators or parasites from approaching. These repellents can be released as sprays, mists, or volatile compounds that create an unpleasant or noxious environment for attackers. For instance, some caterpillars emit chemicals to repel predators, like ants.

d) Sequestration of toxic compounds: Certain insects, particularly those that feed on toxic plants, sequester toxic compounds from their diet and store them in their bodies as a defense mechanism. These stored toxins can make the insects unpalatable or even poisonous to predators. Monarch butterflies and certain beetles are known for their sequestration of toxic compounds called cardenolides.

e) Defensive pheromones: Insects use pheromones, which are chemical signals, for various purposes, including defense. Some insects release alarm pheromones when threatened, alerting conspecifics to the

presence of danger and coordinating a collective defense response. Ants, bees, and termites employ alarm pheromones in this manner (Howse, 1984).

f) **Camouflage chemicals**: Some insects produce chemicals that help them blend into their surroundings or mimic the scents of their environment, enhancing their camouflage and reducing the detection by predators.

It's important to note that insect defense mechanisms can vary greatly across species and depend on factors such as their ecological niche, natural enemies and evolutionary history. These adaptations enable insects to survive and thrive in diverse environments while reducing the risk of predation and parasitism.

Conclusion

Insects' diverse defense mechanisms highlight their evolutionary success in adapting to a range of ecological challenges. Their reliance on behavioral, morphological, and chemical strategies reflects a dynamic interplay between predator pressure and survival. Whether through rapid escape, protective armor, or chemical deterrence, these defenses serve as a testament to the resilience and ingenuity of insects. Understanding these mechanisms not only provides insight into insect survival but also offers potential applications in fields such as biomimicry and pest management. Further study of insect defense can reveal new strategies for ecological balance and the development of bio-inspired technologies.

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INSECT PESTS OF SAFFLOWER AND THEIR MANAGEMENT

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Safflower (*Carthamus tinctorius* L.) is a multipurpose crop with unexploited potential and worldwide adaptability. It is mainly grown for its edible oil in the semi-arid tropics of India, with an area of 109-thousand-hectares, production of 90 thousand tonnes and productivity of 826 kg/ha (www.Indiastat.com, 2022-23). The crop is under threat due to various insect pest attack, which considerably reduces the yield (Singh *et al.,* 1999). It is known to be attacked by 101 insect pest species belonging to different orders (Bharaj *et al.,* 2003; Patil and Halolli, 2005). Of these, hemipterans particularly aphids and lepidopterans like defoliators and capsule borers are causing huge (35 to 100 per cent) economic loss. Some of the major pests reported on safflower include:

1. Safflower aphid, *Uroleucon compositae* (Hemiptera: Aphididae)

In India, six aphid species were reported on safflower. Of these, *Uroleucon compositae* is the most destructive and causes 35 to 72 per cent yield loss during heavy infestation. Its infestation usually starts after one month and continues till flowering. Aphids are black coloured (Fig. 1) and found in colonies on tender parts of the plants like leaves, growing tips, shoots and capsules (Fig. 2 & 3). Nymphs and adults suck the sap from these parts as a result, the leaves fade and then, turn to yellowish and dry-up gradually. Under severe infestation, entire plant dries-up (Fig. 4). Indirectly, they secrete lot of honeydew on the plant which affects the photosynthetic activity. Direct and indirect damage resulted in yield reduction. This pest can be effectively managed by conserving natural enemies by spraying insecticides safer to natural enemies like NSKE @ 5% or cotton seed oil @ 1%, with 0.2% soap solution at 40 days after sowing. Secondly, spray dimethoate 30EC @ 1.7 ml/l or thiamethoxam 25WG @ 0.2 g/l or dust malathion 5D @ 20 to 25 kg/ha at 40 and 60 days after sowing

Figs. 1 - 4. *Uroleucon compositae*, 1. Adult, 2 & 3. Nymphs and adult sucking the sap from tender parts of the plant, 4. Yellowing and drying of plant, with black sooty mould due to honey dew secretion

2. Safflower caterpillar, *Condica capensis* (Lepidoptera: Noctuidae)

It is a major defoliator on safflower in India, causing 62.20 to 100 per cent yield loss due to extensive foliage feeding by large number of larvae. In addition to safflower, it also infests jute, niger, parthenium *etc.* Adult is a medium sized moth. Forewings are darkish-brown to greyish-brown in colour. While hind wings are light brown in colour (Fig. 5). Larva is greenish and smooth bodied, with slightly humped anal segment (Fig. 6). Larvae infest young as well as grown-up plants and cause defoliation (Fig. 7). This pest can be effectively managed by spraying indoxacarb 14.5SC or 15EC @ 0.3 ml/l of water.

Figs. 5 - 7. *Condica capensis*, 5. Adult, 6. Larvae feeding on foliage, 7. Larvae causing defoliation

3. Capsule borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae)

It is considered as one of major pests of safflower in India, causing up to 50 per cent yield loss by directly inflicting damage to flower buds, ovaries and developing seeds inside the capsule (Fig. 9) besides, also feeds on foliage at vegetative stage (Fig. 10) of the crop which results in yield reduction. The damaging symptom can be easily recognised by the presence of circular hole on the capsule (Fig. 9). Adult is medium sized, stout-bodied, dull light brown with dark markings. Forewings are brown to reddish brown in females and dull greenish to yellow or light brown in males. Hindwings have a wide, dark outer margin that contains a small light or pale spot (Fig. 8). To manage this pest, spray chlorantraniliprole 18.5 SC @ 0.15 ml/l or indoxacarb 15EC @ 0.3 g/l.

Figs. 8 - 10. *Helicoverpa armigera*, 8. Adult, 9. Larvae feeding on developing capsule, 4. Larvae causing defoliation.

4. Bordered straw moth, *Heliothis peltigera* (Lepidoptera: Noctuidae)

It is also called as capsule borer and in recent years, it has become a major pest on safflower in Karnataka, especially in northern Karnataka. At vegetative stage, it feeds on foliage leading to defoliation (Figs. 12). At reproductive stage, it damages the developing capsules resulting in seed yield reduction (Fig. 13). The damaging symptom can be easily recognised by the presence of irregular hole on the capsule (Fig. 13). Adult is medium sized, stout bodied, ochreous in colour.

Forewings are usually greyish ochreous, flushed with pale brown and costa with a reniform grey dot. Hindwings with a broad brown-black marginal border, containing a pale blotch (Fig. 11). This pest can be effectively managed by spraying chlorantraniliprole 18.5 SC @ 0.15 ml/l or indoxacarb 15EC @ 0.3 g/l.

Figs. 11 - 13. *Heliothis peltigera*, 11. Adult, 12. Larva feeding on leaves causing defoliation, 13. Larvae feeding on the capsules

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INSECT PESTS OF MILLETS: IDENTIFICATION AND MANAGEMENT STRATEGIES

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Abstract

Millets comprise a varied group of small-seeded annual grasses, cultivated primarily for their grains. Highly nutritious, they serve as a staple food for many of the world's poorest populations. In India, millets have long been an essential part of the diet, particularly in dryland regions where they flourish despite difficult climatic conditions. Globally, eight millet species are cultivated, with pearl millet being the most prominent, while other species like finger millet, foxtail millet, proso millet, barnyard millet, fonio millet, brown top milet and kodo millet are usually grown for family consumption. Millet cultivation, however, encounters challenges from numerous insect pests including aphids, the spotted stem borer, pink stem borer, fall Armyworm, shoot fly, cutworm, and white grub. Traditional pest control methods rely on chemical pesticides, raising concerns about environmental and health impacts. Integrated Pest Management (IPM) has thus gained popularity as a holistic approach to pest control, focusing on reducing pesticide use while maintaining effective management strategies. Various IPM techniques, including the use of biological control agents, crop rotation, clean cultivation, and targeted chemical interventions, are recommended for managing these pests.

Introduction

Millets are a different group of small-seeded annual grasses cultivated for their grains. They are highly nutritious and serve as a staple food for the poorest populations. In the Indian subcontinent, Sub-Saharan Africa, and China, millet grain is a significant food component, while in the United States, it is also used as feed for poultry and cattle. In India, millets have been a vital staple food for centuries, particularly in dryland regions, where they thrive under challenging climatic conditions. Worldwide, eight species of millet are cultivated. Among them, pearl millet (*Pennisetum glaucum*) is the most prominent, while the other varieties are smaller millets typically grown for family consumption. These include finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), kodo millet (*Paspalum scrobiculatum*), proso millet (*Panicum miliaceum*), little millet (*Panicum sumatrense*), barnyard millet (*Echinochloa colona*), fonio millet (*Digitaria spp.*), and brown top millet (*Brachiaria ramosa*). In recent years, millet production has risen. The growing market demand for millet has led farmers to cultivate it either as a sole crop or intercropped with legumes. Further, the Indian government, recognizing the importance of millets, has launched several development initiatives to promote the cultivation and consumption of millets. For instance, in 2018-19, the Government of India declared millets as 'Nutri-Cereals' and launched the 'National Mission on Nutri-Cereals' to increase their cultivation and promote consumption. In India, at least 116 insect species have been documented feeding on millets (Kishore, 1996), with many of these pests affecting all millet species (Gahukar, 1989). Traditional pest control methods frequently depend on chemical pesticides, which raise concerns about environmental pollution, pesticide residues, and health risks. As a result, Integrated Pest Management (IPM) has become increasingly popular as a

comprehensive strategy for managing pests, focusing on reducing pesticide use while ensuring effective pest control.

Identification of different insect pest infestation of millets:

1.Aphid (*Rhopalosiphum maidis, Aphididae, Hemiptera):* Colonies of both nymph and adult aphids can be seen in the central leaf whorl, stems, or panicles, where they feed on plant sap. Severe infestations lead to marginal leaf necrosis, and stunted plant growth. Additionally, aphids produce honeydew, which supports the growth of molds.

Management

- Yellow sticky trap can be used to monitor the adult aphid.
- Roughing of heavily infested plants.
- Clean cultivation.
- Use of predators such as lacewing (*Chrysoperla* spp), *Aphidioletes aphidimyza*; parasitoids like *Aphilinus abdominalis* can be used.
- In case of heavy infestation Imidachloprid 17.8 SL @ 3ml/lt of water can be used.

2. Root aphid (*Tetraneura nigriabdominalis**,** Aphididae, Hemiptera):* Infested plants become pale yellow and stunted, and may exhibit wilting and drying in patches.

- Proper irrigation should be done.
- Crop rotation with non host crops.
- Clean cultivation should be done.
- In case of heavy infestation Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5% ZC (50ml/acre) @ 0.25 ml/litre; Imidachloprid 17.8 SL @ 3 lt/ lt of water can be used.

3. Spotted stem borer (*Chilo partellus*, Crambidae, Lepidoptera): Newly hatched larvae feed on the leaves, creating pinholes. They then bore into the developing stalk and meristem, causing the leaf whorl to dry up, a condition known as "dead heart."

Management:

- Collection and destruction of the stubbles.
- Remove and destroy dead hearts.
- Deep summer ploughing.
- Planting of Napier grass in the boundary as a trap crop.
- Inter-crop with cowpea in 2:1 ratio.
- Two releases of Trichogrammachilonis 8 cards/ha (1,50,000 parasitized eggs/ha) at 7 and 15 days after germination.
- When infestation crosses 10%, spray Chlorantraniliprole 18.5 SC @150ml/ha.

4. Pink stem borer (*Sesamia inferens*, Noctuidae, Lepidoptera): Larva bore into the central shoot, causing the growing point to dry up and resulting in a "dead heart" in young plants. The larvae create circular tunnels inside the stem, with exit holes at the surface and tunnels filled with excreta, sometimes leaving circular ring-like cuts on lower internodes.

Management:

- Collection and destruction of the stubbles
- Deep summer ploughing
- Removal and destruction of dead hearts.

- Natural Enemies Egg: parasitoid: *Trichogramma chilonis*, Larval parasitoid: *Cotesia flavipes*; Predators: *Chrysoperla carnea*, coccinellid, spider, ear wig, dragon fly, preying mantid, Pentatomid bug.
- When infestation crosses 10%, spray chlorantraniliprole 18.5 SC @150ml/ha.

5. Fall Armyworm (*Spodoptera frugiperda*, Noctuidae, Lepidoptera): The Fall Armyworm (FAW) attacks maize at all growth stages, from seedling emergence to ear development. Young larvae feed by scraping and skeletonizing the upper epidermis of whorl leaves, creating silvery spots and pinholes. Older larvae, starting from the 4th instar, cause extensive leaf defoliation and leave large amounts of fecal pellets in the whorls. Damage during the vegetative stage affects leaves, while damage during the reproductive stage can harm tassels or bore into corn ears, consuming kernels. FAW damage to whorls leads to significant yield loss, while ear feeding impacts both yield and quality.

Management:

- Deep plough the fields to expose pupae to sun light and predatory birds.
- Hand picking and destruction of larvae boring into ears.
- Maintain field bunds clean and plant flowering plants such as marigold, sesame, niger, sunflower, coriander, fennel etc. to attract natural enemies.
- Follow ridge and furrow planting method instead of flat bed sowing.
- Intercrop millets with legumes, viz., pigeonpea, cowpea, black gram, kidney bean etc. in 2:1 to 4:1 ratio
- First spray should be with 5% neem seed kernel extract (NSKE) or azadiractin, 1500 ppm (1 litre/acre) @ 5ml /litre.
- Two release of egg parasitoids viz., *Telenomus remus* @ 4000/ acre or *Trichogramma pretiosum* @ 16,000/acre at weekly interval.
- If infestation is more than 10%, whorl application of Chlorantraniliprole 18.5 SC (80 ml/acre) @ 0.4 ml/litre; Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5% ZC (50ml/acre) @ 0.25 ml/litre; Spinetoram 11.7 % SC (100ml/acre) @ 0.5 ml/litre; Emamectin benzoate5% SG (80g/acre) @ 0.4g/litre is recommended.

Shoot fly (*Atherigona soccata*, Muscidae, Diptera): Maggots bore into the shoot while feeding, gradually killing the growing point and causing the central shoot to wither, a condition known as "dead heart," which can develop within two weeks of germination.

Management:

- Collection and destruction of infested plant parts like dead hearts.
- Seed treatment with imidacloprid 600 FS @ 6 ml/kg seed or Thiamethoxam 30 FS @ 8.0 ml per kg seed.
- Use of natural enemies like: Coccinellid, spider, robber fly, pentatomid bug, ear wigs.

Cutworm (*Agrotis ipsilon*, Noctuidae, Lepidoptera): Young larvae feed on the leaf epidermis, while older larvae come out at night to cut the stems of young plants. They consume less but cause more damage.

Management:

- Flood the infested fields.

- Handpick and destroy the larvae in morning and evening hours on cracks and crevices in the field.
- Plough the soil during summer months to expose larvae and pupae to avian predators.
- Set up light trap @1/ha Pheromone traps @12/ha to attract male moths.
- Spray insecticides like chlorpyriphos 20 EC @1 lit/ha or neem oil @ 3%.

White grub (*Holotrichia serrata*, Scarabaeidae, Coleoptera): grub feed on roots, yellowing of leaves.
Management:

- Light trap installation for management as adults are attracted to light.
- Shaking of higher trees in evening followed by collection and destruction of beetles.
- Soil drenching of chlorpyriphos 20EC @ 2ml/litre of water.

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GLYCOMACROPEPTIDE: A NOVEL APPROACH TO NUTRITIONAL MANAGEMENT OF PHENYLKETONURIA IN INFANTS

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Introduction

A shortage or malfunction in the enzyme phenylalanine hydroxylase (PAH) or its cofactor, tetrahydrobiopterin (BH4), results in phenylketonuria (PKU), a hereditary illness. The amino acid phenylalanine (Phe) is changed into tyrosine by this enzyme. Phenylalanine is improperly processed when this enzyme is absent or functions improperly, causing it to build up in the blood and brain. Elevated phenylalanine levels are neurotoxic to the brain, resulting in serious health problems associated with neurological development. PKU is inherited in an autosomal recessive pattern, meaning that both parents must carry a copy of the mutated gene for their child to be affected (Pena et al., 2018). If both parents are carriers, there is a 25% chance with each pregnancy that their child will inherit PKU. PKU carriers and pregnant women with PKU are at risk for developing maternal PKU syndrome, which can result in low birth weight, congenital heart abnormalities, and developmental problems in the offspring if phenylalanine levels are not properly controlled during pregnancy (Tosi et al., 2024). PKU symptoms can range widely in intensity, but typically involve behavioral or social issues, intellectual incapacity, and developmental delays. Additionally, typical are neurological symptoms such tremors, hyperactivity, and seizures. Furthermore, because of the accumulation of Phe, people with PKU may develop skin disorders like dermatitis and eczema. Early detection and diagnosis are crucial in reducing the severity of PKU patients, as there is currently no known cure for the condition. Newborns with PKU are usually detected through regular screening tests that are performed soon after delivery. The Guthrie test, a kind of newborn screening in which a tiny blood sample is taken from the infant's heel (heel prick test), is the main diagnostic technique. This blood sample is examined for increased Phe concentrations. Elevated Phe levels signify the existence of PKU, facilitating prompt intervention and care (Tosi et al., 2024).

Dietary changes are the mainstay of PKU management, as they regulate the body's Phe levels. Three fundamental ideas underpin the course of treatment:

1. Natural Protein Restriction: This strategy lowers the quantity of Phe ingested by restricting the consumption of foods high in natural protein.
2. Integration with Protein Substitutes Free of Phe (PSs): Protein replacements free of Phe are used to make sure patients get enough nourishment. With the exception of Phe, these replacements offer the essential amino acids that are normally found in naturally occurring protein sources.
3. Low-Protein Food (LPF) Consumption: It is recommended that people with PKU consume low-protein foods that have been properly prepared to help control Phe levels while still satisfying their caloric demands (Rondanelli el al, 2023).

For newborns to maintain optimal physical and mental health, dietary management must start as soon as the diagnosis is made and continue throughout life. Strict devotion to the diet for the rest of one's life is required to avoid neurological problems and cognitive impairment that are linked to high Phe levels. Strict attention to the diet is especially important for PKU pregnant women in order

to prevent maternal PKU syndrome, which can negatively impact fetal development and result in congenital impairments, growth limits, and other issues. Although there isn't a cure for PKU at this time, people with the illness can greatly enhance their quality of life and health outcomes with early diagnosis and lifetime dietary therapy.

Understanding Glycomacropeptide (GMP): A Protein Substitute for PKU

Protein substitutes are essential for individuals with PKU as they provide the necessary amino acids required for the synthesis of vital proteins, enzymes, and hormones, which are crucial for proper growth, development, and metabolic processes. Because Glycomacropeptide (GMP) naturally contains less Phe, it is a useful protein alternative for patients with PKU. GMP is a glycophosphopeptide of 64 amino acids that is produced during the manufacturing of cheese from casein, more precisely from whey protein (Perotti et al., 2022). Chymosin, an enzyme, breaks down bovine κ-casein into para-κ-casein and GMP. The absence of aromatic amino acids like phenylalanine, tyrosine, and tryptophan as well as arginine, cysteine, and histidine makes pure GMP special. Because of this, it's a great source of protein for PKU sufferers who have to closely monitor their Phe consumption. Neutral amino acids such as isoleucine and threonine are found in higher concentrations in GMP; two to three times higher than in other proteins. During the isolation and purification process, commercial GMP may be slightly contaminated with whey proteins that contain phenylalanine, resulting in a phenylalanine level of 2.5 to 5 mg per gram of protein. GMP products, however, are modified to guarantee that they offer a sufficient quantity of protein while maintaining low Phe levels. It has been demonstrated that GMP dramatically lowers brain and plasma Phe levels. Large neutral amino acids (LNAAs) in GMP compete with phenylalanine for absorption and passage across the blood-brain barrier, which contributes to this in part (Ahring et al,2022). This rivalry lessens the negative effects of Phe by lowering its levels in the brain.

Clinical research on GMP-based protein replacements has shown that there are a number of advantages for PKU sufferers. Increased satiety is a key benefit; GMP consumption is linked to better sensations of fullness, which aids PKU patients in better food management. High nutritional quality is another benefit of GMP, guaranteeing that patients get nutrients and necessary amino acids without running the risk of phenylalanine overdose. Furthermore, patients find it simpler to continuously comply to the stringent dietary regimen needed for managing PKU because of the palatability and nutritional advantages of GMP (Russo el al,2024). Reduced obesity-related comorbidities are another noteworthy advantage; GMP consumption has been associated with lower incidence of obesity-related health problems, which are a major worry for some PKU patients because of dietary imbalances. Because of these advantages, GMP is a useful protein replacement for PKU management, offering a nutritious, safe, and well-balanced choice that complies with PKU patients' dietary limitations. GMP-based protein replacements, like the ones shown in Fig. 1, are commercially accessible and specially designed to fulfill the dietary requirements of people with PKU. This allows them to maintain healthy phenylalanine levels while still receiving enough nourishment.

Fig. 1: Commercially viable protein substitute based on GMP

GMP's Unique Benefits for PKU Babies

For newborns with PKU, GMP provides a number of special advantages that make it a great option for early nutritional management.

1. Phe-Free Composition: GMP has a naturally low Phe content, so there's no need to worry about any negative side effects when infants eat it. Because of its Phe-free product, newborns can absorb important proteins without worrying about high Phe levels, enabling safe and efficient management of PKU from an early age.
2. Nutritional Support: GMP is low in Phe and offers a comprehensive nutritional profile that includes all the vital amino acids, vitamins, and minerals needed for an infant's healthy growth and development. For newborns with PKU, it is essential that they have a balanced source of protein that supports proper physiological development.
3. Easy Digestibility: GMP is well known for being highly digestible, which makes it especially suitable for newborns, whose digestive systems are still maturing. Its simple breakdown in the digestive system guarantees the best possible absorption and utilization of nutrients, which is essential for promoting the development and well-being of infants with PKU.
4. Improved Acceptance and Palatability: Since they have a direct bearing on following dietary recommendations, the acceptability and palatability of protein replacements are important considerations in baby feeding. GMP-based alternatives are frequently commended for having a pleasing flavor and texture, which helps babies with PKU find them more palatable.(Russo el al, 2024)Better palatability makes these replacements more palatable to babies, which facilitates smoother feeding experiences for both baby and caregiver. This improves adherence to the nutritional control recommended for PKU.
5. Convenience: Ready-to-feed liquids and powders are only two of the convenient forms in which GMP-based protein substitutes are offered. These formats provide flexibility in satisfying the dietary needs of PKU newborns without compromising Phe control. They can be easily included into infant feeding practices, for example, by mixing into formula or fortifying meals.

Because of these special advantages, GMP is a very useful protein replacement for babies with PKU. It meets their nutritional requirements, encourages healthy growth, and makes diet management easier for both the baby and the caregiver.

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JELLYFISH BLOOMS: CAUSES, CONSEQUENCES, AND MANAGEMENT STRATEGIES IN PULICAT LAKE, TAMIL NADU

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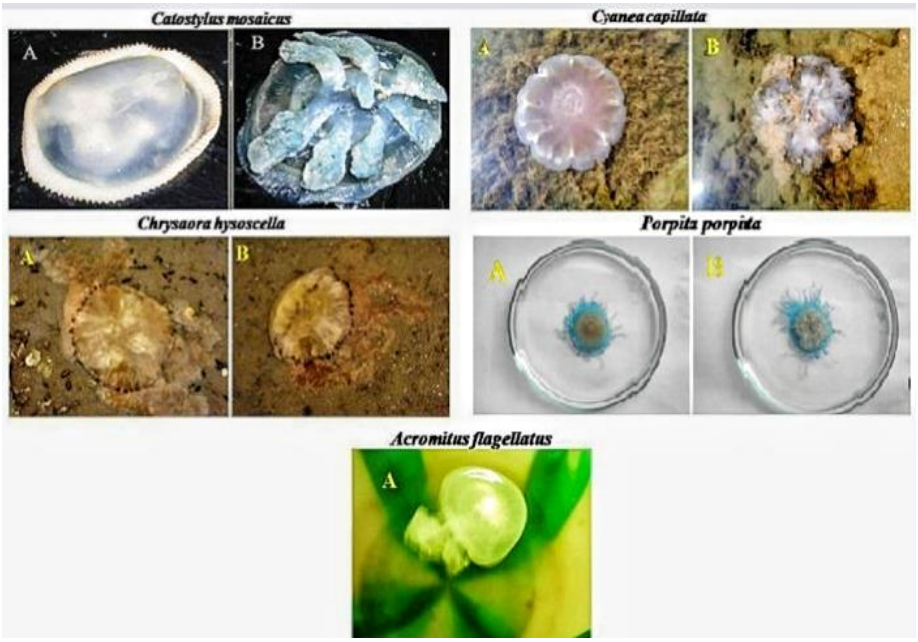
Introduction

Jellyfish blooms are rapid and dense increases in jellyfish populations within marine ecosystems, occurring more frequently due to both natural and human-induced factors. While ocean currents and temperature naturally influence these blooms, human activities like overfishing, climate change, and pollution have intensified their occurrence. Overfishing removes jellyfish predators, and warming waters with nutrient-rich pollution create favorable breeding conditions. These blooms disrupt marine food webs, damage fisheries, and hinder tourism by clogging nets and stinging swimmers. Managing jellyfish blooms requires better marine practices and continued research to mitigate their environmental and economic impacts.

Species Diversity and Distribution

Pulicat Lake, one of the largest brackish water lagoons in India, hosts a diverse range of jellyfish species. Research indicates that the lake is home to several species of jellyfish, including Catostylus mosaicus, Acromitus flagellates, Cyanea capillata, and Chrysaora hysoscella. These species belong to different families such as Catostylidae, Cyaneidae, and Pelagiidae.The distribution of jellyfish in Pulicat Lake is influenced by various factors, including water salinity, temperature, and the availability of prey. Jellyfish populations tend to be more abundant in areas with higher salinity and are often found near the Barmouth region of the lake. Seasonal variations also play a significant role, with certain species being more prevalent during specific times of the year.



Environmental and Biological Causes

Jellyfish blooms, which are substantial increases in jellyfish populations, can be triggered by a combination of environmental and biological factors. Environmental causes include eutrophication, where excessive nutrients in the water from agricultural runoff lead to large algal blooms. When these algae die and decompose, they create low-oxygen conditions (hypoxia) that jellyfish can tolerate better than many other marine species. Rising ocean temperatures also accelerate jellyfish reproduction and growth, leading to more frequent and larger blooms. Coastal development and human activities such as construction and land reclamation can alter coastal ecosystems, creating favorable conditions for jellyfish. Additionally, climate change affects ocean currents and temperatures, redistributing jellyfish populations and increasing bloom occurrences. On the biological side, overfishing depletes jellyfish predators like certain fish and turtles, removing natural population controls and allowing jellyfish numbers to surge. Jellyfish have naturally high reproductive rates, which can lead to rapid population increases under favorable conditions. Furthermore, jellyfish can survive in low-oxygen environments that are inhospitable to many other marine organisms, giving them a competitive advantage. These factors often interact, creating complex dynamics that can lead to sudden and massive jellyfish blooms.

Ecological consequences

Jellyfish blooms can have significant ecological consequences, impacting marine ecosystems in various ways. They disrupt food webs by consuming large quantities of plankton, which are a primary food source for many marine species, leading to a reduction in available prey for higher predators such as fish and seabirds. Additionally, jellyfish blooms can alter nutrient cycles by excreting waste that shifts nutrient availability to microbial communities, affecting overall ecosystem health. These blooms also impact fisheries by competing with fish for food and habitat, potentially leading to declines in commercial fish stocks and economic consequences for fisheries and local communities. Furthermore, jellyfish can damage coastal infrastructure by clogging cooling water intakes of power plants and desalination plants, causing operational disruptions, as seen in the shutdowns of nuclear power plants in Scotland and Sweden. Lastly, jellyfish blooms can affect coastal tourism by making swimming and other recreational activities dangerous or unpleasant due to the risk of stings. These impacts highlight the importance of monitoring and managing jellyfish populations to mitigate their effects on marine ecosystems and human activities.

Economic and social impacts

Jellyfish blooms have significant economic and social impacts, particularly in coastal regions. In the fishing industry, these blooms disrupt operations by clogging nets, damaging equipment, and reducing fish populations through predation on larvae and competition for plankton, leading to lower profits and increased costs for fishermen. Coastal tourism is also affected, as the threat of jellyfish stings often leads to beach closures, negatively impacting businesses that depend on tourism, such as hotels and recreational services. In aquaculture, jellyfish can invade farms, stinging or killing farmed fish, causing significant financial losses. Additionally, power plants and desalination facilities face operational shutdowns and increased maintenance costs when jellyfish clog their cooling or intake systems, reducing energy and water output. On a social level, jellyfish stings pose health risks to beachgoers, leading to increased medical expenses and, in severe cases, fatalities, straining local healthcare systems. Furthermore, jellyfish blooms disrupt marine ecosystems by consuming plankton and altering predator-prey relationships, affecting biodiversity and the

sustainability of marine resources that many coastal communities rely on for their livelihoods. Addressing these impacts requires improved marine management, early warning systems, and public education to mitigate the risks associated with jellyfish blooms.

Monitoring and prediction

Monitoring and predicting jellyfish blooms is essential for mitigating their negative impacts on marine ecosystems and human activities. Advanced technologies, such as satellite imagery, oceanographic sensors, and drones, play a key role in tracking jellyfish populations and identifying environmental factors that trigger blooms, such as changes in sea temperature, salinity, and nutrient levels. These tools enable researchers to monitor jellyfish distribution in real-time and detect patterns in bloom formation. Additionally, predictive models use historical data, including ocean conditions and jellyfish life cycles, to forecast future blooms, allowing for early warning systems that can help industries like fishing, tourism, and aquaculture prepare and respond effectively. Citizen science initiatives, where the public reports jellyfish sightings, also contribute to bloom monitoring efforts. Combining these strategies enhances our ability to predict and manage jellyfish blooms, minimizing their ecological, economic, and social consequences.

Management and mitigation strategies

Managing and mitigating jellyfish blooms requires a combination of ecological, technological, and awareness-based strategies. Sustainable fishing practices and reducing pollution help restore the balance between jellyfish and their natural predators while preventing nutrient-rich runoff that encourages blooms. Technological measures, such as installing barriers and filtration systems, protect key industries like aquaculture and power plants from jellyfish intrusion. Early warning systems, based on predictive models and real-time monitoring, allow for proactive responses to blooms. Public education campaigns also raise awareness of bloom risks and promote safe practices. Additionally, research into biological controls, such as boosting jellyfish predators, and international cooperation can further enhance bloom management efforts, minimizing their environmental and economic impacts.

Case studies

Jellyfish blooms, characterized by the rapid increase in jellyfish populations, have been documented in various parts of the world, often with significant ecological and economic impacts. For instance, in the Bohai Sea of China, researchers used environmental DNA (eDNA) metabarcoding to study the biodiversity and distribution of blooming jellyfish. They identified six dominant species, including Aurelia coerulea and Nemopilema nomurai, which showed distinct vertical and horizontal distribution patterns. Another notable case is the giant jellyfish blooms in Japan, which have caused substantial disruptions to fisheries and coastal industries. These blooms are often linked to changes in environmental conditions such as temperature, salinity, and nutrient levels. Jellyfish blooms in India have been increasingly documented along various coastal regions, significantly impacting both the environment and local economies. For instance, a study spanning four decades (1980-2020) highlighted frequent jellyfish aggregations and beach strandings across more than 23 coastal locations in India, including Puri, Chennai, Goa, and Mumbai.

Future directions in jellyfish blooms research

Future research on jellyfish blooms is poised to focus on several key areas to better understand and mitigate their impacts. One promising direction is the integration of advanced technologies such as environmental DNA (eDNA) metabarcoding and remote sensing to monitor jellyfish populations and

their movements more accurately. Additionally, there is a growing interest in studying the effects of climate change on jellyfish bloom dynamics, particularly how rising sea temperatures and ocean acidification influence their proliferation. Researchers are also exploring the socio-economic impacts of jellyfish blooms, aiming to develop strategies to protect fisheries, tourism, and coastal infrastructure. Collaborative international efforts and interdisciplinary approaches will be crucial in addressing the complex ecological and economic challenges posed by jellyfish blooms. By advancing our understanding of these phenomena, scientists hope to develop more effective management and mitigation strategies to safeguard marine ecosystems and human activities.

Conclusion

In conclusion, jellyfish blooms represent a complex and growing challenge for marine ecosystems and human activities worldwide. The increasing frequency and intensity of these blooms, driven by factors such as climate change, overfishing, and habitat modification, underscore the need for comprehensive research and innovative management strategies. By leveraging advanced technologies and fostering international collaboration, scientists aim to better understand the dynamics of jellyfish populations and mitigate their adverse impacts. Continued efforts in this field are essential to protect marine biodiversity, support sustainable fisheries, and safeguard coastal economies from the disruptions caused by jellyfish blooms. In Pulicut lake, every year Jellyfish bloom is observed during the summer season and it hinders fishing activities in the region. Also, itching and injury to fishermen takes place during this bloom timing. Mostly, the jellyfish enters the lake through coastal waters and in few cases, breeding also takes place in the lake water. There is an urgent need to undertake research in this line to control jellyfish algal bloom in Pulicut lake to suggest suitable control methods to overcome the problem of Jellyfish algal bloom.

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UNLOCKING NATURE'S POWER: THE FUTURE OF BIOENZYMES IN SUSTAINABLE SOLUTIONS

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Abstract
In the contemporary era, where environmental stewardship is paramount, discovering sustainable solutions to diverse challenges is imperative. Bioenzymes are a notable alternative to conventional chemical-based products, presenting many environmental and well-being advantages. Bioenzymes are derived through the fermentation of organic waste materials. Due to their diverse domestic, agricultural, and environmental applications, they are also recognized as multi-purpose liquids. The presence of secondary metabolites within bioenzymes endows them with antibacterial, antifungal, insecticidal, and foaming properties. Bioenzymes are a cost-effective, biodegradable, organic, and environmentally friendly alternative to commercially available chemical products. They do not contaminate water or soil systems, release toxic fumes, or pose harmful effects on humans or animals.

About Bioenzymes
India's rising population has increased waste, harming the economy and environment (Yadav & Singh, 2021). According to available data, India generates approximately 147,613 metric tonnes of solid waste daily (Singh, 2020). Organic waste is a significant component of municipal solid waste, mainly comprising wet kitchen waste such as fruits and vegetable peels, food waste, landscape debris, and pruning waste (Rasit & Kuan, 2018). When disposed of directly in landfills, these wastes undergo anaerobic decomposition due to the action of microorganisms, resulting in landfill gas production, further contributing to global warming and accounting for alterations in climatic conditions (Rungta *et al.,* 2022).

In 2006, **Dr. Rosukon Poompanvong** from Thailand developed a complex solution fabricated from organic solid waste called "**Garbage Enzyme**." Most people also know that Garbage Enzymes are Bio-Enzyme, EcoEnzyme (Sethi *et al.,* 2021), Trash Enzyme, or Fruit Enzyme (Vrishti *et al.,* 2023). It is a gloomy brown solution with a vinegar-like aroma. It mainly consists of alcohol, acetic acid, vitamins, minerals, salts, enzymes like amylase, cellulase, lipase, protease, amino acids, hormones, and some good microbes. Bioenzyme is produced by simple fermentation of organic wastes like fruits and vegetable peels, flowers, or leaves accompanied by molasses and water. All the above ingredients are mixed in the 3:1:10 ratio, i.e., three parts of organic waste (peels, leaves and flowers), one part of molasses (jaggery), and ten parts of water. This solution is then allowed to ferment for three months (Lakra *et al.,* 2022; Sethi *et al.,* 2021).

Here, firstly, the naturally occurring yeast and bacteria present on the surfaces of fruit and vegetables without oxygen breaks down the sugar molecules such as glucose, sucrose, and fructose into a cellular energy Adenosine Triphosphate (ATP). The fermentation process yields ethanol and carbon dioxide as secondary products. Despite oxygen, certain yeast species, such as

Saccharomyces cerevisiae and *Zymomonas mobilis* (a Gram-negative, facultative anaerobic bacterium), can produce ethanol. Then, the alcohol is further oxidized to acetic acid with the help of acetic acid bacteria, often found abundantly in air, water, fruit and vegetable residue, fermented products containing alcohol, and food materials containing sugar (Rungta *et al.,* 2022; Sahu *et al.,* 2024).

The chemical properties of these bioenzymes are similar to those found in other biological systems. Bioenzymes harbor a trove of secondary metabolites, including alkaloids, flavonoids, quinones, saponins, tannins, and cardenolides. These compounds are renowned for their diverse biological activities, including insecticidal, anti-feedant, anti-microbial, anti-oxidant, and foaming properties (Rungta *et al.,* 2022; Sethi *et al.,* 2021). It serves multiple purposes: natural cleaning agent, fertilizer, herbicide, pesticide, water purifier, air purifier, drain unclogger, and soil enhancer. The substance can serve as a bio-remediation agent to eliminate heavy metals from polluted soil and facilitate the bio-catalytic remediation of oil-contaminated soil (Vrishti *et al.,* 2023).

Agricultural Uses of Bioenzymes

India, an agrarian nation, faces challenges in agricultural production due to climate change, inadequate rainfall, and nutrient-deficient soils. Farmers often use chemical fertilizers and pesticides which may initially yield positive results but lead to long-term soil infertility and groundwater contamination. A practical and sustainable solution is the utilization of natural fertilizers like bio-enzymes. Bio-enzymes enhance soil quality, stimulate healthy plant growth, and mitigate pest infestations, ultimately ensuring the perpetual prosperity of India's agricultural sector.

a) **Bioenzyme as Natural Fertilizer:** Chemical fertilizers can harm farm soil and lower crop production due to their high nitrogen content, which increases soil acidity. Bio-enzymes, a natural alternative, can address these issues. Bio-enzymes revive barren land into fertile farms by converting ammonia in the soil to nitrate and purify contaminated groundwater. Diluted bio-enzyme acts as a liquid nutrient for the soil and is highly beneficial. Bio-enzymes, being all-natural and organic, can be used efficiently as natural fertilizers to deal with the disadvantages of chemical fertilizers (Hunt 2020; Sethi *et al.,* 2021).

   Banana peels and neem leaves, rich in macronutrients (such as potassium, magnesium, calcium, sodium, and phosphorous) and micronutrients (such as iron, zinc, manganese, and copper), act as natural fertilizers for Cosmos plants, enhancing growth and development. Bioenzymes in the peels provide vitamins, amino acids, and hormones, promoting soil nourishment and plant resilience against abiotic stresses (Rungta *et al.,* 2022; Sethi *et al.,* 2021).

b) **Bioenzyme as Natural Pesticide and Herbicide:** Bioenzyme, a natural pest repellent, can control plant infection and drive away disease-causing microbes, viruses, insects, and rodents from farmland. It also enhances plant growth and effectively kills weeds when used in concentrated form. Farmers in India have successfully applied eco-enzymes on crops and observed positive results, including increased plant size and reduced pest attacks. Bio-enzyme can be efficiently used as a natural insecticide and herbicide, making it a favorable option for plantation and farming (Sethi *et al.,* 2021).

   Neem bioenzymes effectively control pests on Tulsi plants. Azadirachtin, Nimbolide, and Salannin are the main active compounds in neem leaves. Azadirachtin disrupts insect growth

and development, preventing molting and metamorphosis. Nimbolide B and nimbic acid have herbicidal properties. Salannin mimics insect hormones, damaging growth and reproduction (Rungta *et al.,* 2022; Sethi *et al.,* 2021).

c) **Overall Nourishment for Vegetables and Fruits:** Using bioenzymes as a natural soil amendment enhances plants' photosynthesis, nutrient, and water uptake, improving the quality and quantity of fruits and vegetables. Ozone released by eco-enzymes accelerates plant growth, reducing the cultivation period. Dried leftover residue enriches the soil with earthworms, promoting natural plant growth (Sahu *et al.,* 2024). Bio-enzyme granules ensure uniform crop growth, resilience to stress and drought, and reduced premature flower and fruit dropping. Eco-enzymes provide a sustainable and eco-friendly approach to enhance agricultural productivity and crop quality (Sethi *et al.,* 2021).

d) **Beneficence to Livestock:** Eco-enzyme, with antiviral and antibacterial properties, can disinfect livestock areas, eliminate odors, and promote a germ-free environment. It enhances animal immunity, increasing the production of high-quality milk, poultry, and meat products (Sethi *et al.,*2021).

Non-Agricultural Uses

Bioenzyme offers various non-agricultural applications. It helps in air purification by removing odors, killing germs, and acting as a natural air purifier. It is a chemical-free alternative for cleaning, repelling insects, cleaning fittings, and removing stains. Bioenzyme reduces carbon dioxide levels and purifies the air from pollutants. It unclogs and drains efficiently with its microorganisms. In personal care, it has antibacterial and antifungal properties and can be used in skin and hair care products. It acts as a natural detergent for laundry, removing dirt and grease while preserving fabric quality. Bioenzyme minimizes solid waste by converting organic waste into garbage enzymes, reducing municipal solid waste and landfill leachate generation (Lakra *et al.,* 2022; Vrishti *et al.,* 2023).

Future Perspective of Bioenzyme and summary

Bioenzymes, derived from nature's catalytic prowess, offer an eco-friendly and sustainable alternative to conventional chemical processes. They revolutionize industries by boosting efficiency and optimizing enzymatic synthesis and biofuel production costs. In agriculture, biofertilizers and biopesticides enhance crop productivity and sustainability. Biomedicine utilizes bioenzymes for disease diagnosis and drug discovery (Benny *et al.,* 2023). Prospects encompass synthetic biology and nanotechnology, enabling bio-based manufacturing and advanced biomaterials. Harnessing bioenzymes is crucial for addressing environmental challenges and fostering scientific innovation across multiple domains. Embracing bioenzymes symbolizes a commitment to a sustainable future where scientific progress aligns with environmental stewardship. Bioenzymes are vital to tackling global issues, driving economic growth, and safeguarding the well-being of future generations.

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HIDDEN THREATS: HOW MICROPLASTICS ARE DISRUPTING FISH REPRODUCTION

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Abstract

Microplastic (MP) pollution of the marine environment is becoming a major worldwide concern, due to its ability to enter and spread across food webs. It poses a hazard to a multitude of species. Because of the chemical additives used to produce many plastic items and the persistent organic pollutants that may build up on them while they are in the environment, this is seen as a potential toxicological danger to marine creatures. Plastics typically break down into smaller particles in the marine environment due to mechanical, biological, and photodegradation processes. These MPs may be hazardous to humans and a wide range of aquatic animals, which has sparked worries around the world. Fish that consume microplastics may experience serious health problems, such as decreased appetite, abnormal gill function, immunosuppression, and decreased reproducibility. This article provides a summary about the impact of microplastics in fish reproduction.

Introduction

Plastic pollution poses a serious threat to aquatic ecosystems around the world. Microplastics are plastic fragments smaller than five millimeters. They have been found in freshwater and marine environments along beaches, in sediment, and in the water column itself in aquatic systems throughout all seven continents. Microplastics can be found in the wild from a variety of sources, such as the decomposition of larger plastic objects like drink or food containers, synthetic clothing fibers, industrial waste, and parts of some cosmetics. Because of their longevity and versatility, plastics (long polymer chains) are widely used, which has resulted in a significant buildup of plastic debris in the environment. Polyethylene (PE), Polypropylene (PP), Polystyrene (PS), Polyethylene Terephthalate (PET), and Polyvinyl Chloride (PVC) are the most prevalent plastic polymers found in the environment.

Additionally, plastic polymers can undergo changes in size (to become macro-, micro-, and nanoplastics) and shape (to become spheres, fibers, and fragments) when exposed to heat, UV light, waves in an aquatic environment, or biological deterioration. Similar to the aging of plastic particles, these processes cause Microplastics (MP) and Nanoplastic (NP) to weather in the environment, which improves the leaching of chemicals from these pollutants. Bisphenol A, polychlorinated biphenyls, and estrogenic and anti-estrogenic phthalates are examples of endocrine disrupting chemicals (EDCs) that are added to plastics and interact with both human and animal biology. Moreover, MPs and NPs can absorb a variety of environmental pollutants due to their large surface area to volume ratio, including hydrophobic persistent organic pollutants (POPs), pesticides, heavy metals, pathogenic microorganism and polycyclic aromatic hydrocarbons (PAHs), which also function as EDCs.

Microplastic accumulation has been extensively documented in a wide range of aquatic and terrestrial fauna. Significant negative effects on animal development and health have been

documented by these studies. These effects include alterations in behavior, neurological damage, increased oxidative stress, inflammation, genotoxicity, reduced body size, decreased survival rate and reproduction, altered motility, altered behavior, as well as variations in the microbiome. It has recently been demonstrated that NPs are passed on to the progeny of zebrafish mothers exposed to NPs, indicating that MPs and NPs may have an effect on the health of several animal generations as well as possibly human generations.

Entry of microplastic in aquatic organism

Numerous possibilities allow microplastics to enter aquatic species, potentially causing harm. Because of their small size and similarity to natural prey items like plankton or fish eggs, microplastics are frequently mistaken for food by aquatic creatures, including fish, plankton, and invertebrates. In their quest for food, bivalves (such as mussels and clams) and some fish species filter water, unintentionally bringing microplastics suspended in the water into their mouths. Microplastics may go up the food chain when prey that has already consumed them is eaten by predatory species.

Through their gills, fish and other gill-breathing creatures can directly absorb microplastics while getting oxygen from the water. microplastics in water have the potential to lodge in the gill structures and make their way into the organism's bloodstream. Aquatic organisms' skin can be penetrated by certain microplastics, particularly the smaller nanoparticles. This is particularly prevalent in animals with porous skin, such certain fish species and amphibians. Microplastics may stick to the mucous layers of organisms with mucous skin. These particles can then be absorbed or consumed as the organism’s groom or eat.

Microplastics that have settled in the sediment may be consumed by organisms that feed on or inside sediments, such as some worms, crustaceans, and fish species. This is an important pathway of exposure for organisms that are benthic, or bottom-dwelling. Detritus, or organic debris that has broken down, is consumed by certain aquatic organisms and may contain microplastics.

Microplastics can travel up the food chain from tiny organisms to larger predators by ingestion. As a result of this trophic transmission, microplastics may accumulate and concentrate at higher trophic levels in a process known as bioaccumulation. There is a higher chance of exposure for aquatic life that resides in contaminated areas with high levels of microplastics in the water by ingestion, absorption, or direct touch.

Microplastic (mp) impacts on reproduction

An organism's fecundity can be negatively impacted by undernutrition because reproduction is an energy demanding activity. When anything negatively affects a marine animal's gametogenesis, gamete and oocyte quality, fecundity, egg production, or sperm swimming speed, it is referred to as reproductive toxicity. There is lack of information regarding the ecotoxicological effects of MPs on marine animal reproduction.

A range of synthetic polymers, including plasticizers, stabilizers, and flame retardants, are the building blocks of microplastics. Particularly in aquatic systems, these compounds have the potential to seep into the surrounding environment from the plastic particles.

Endocrine-Disrupting Chemicals (EDCs): A few of these additions are known to cause disruptions to the endocrine system, including phthalates, polychlorinated biphenyls (PCBs), and bisphenol A

(BPA). Unbalances can result from EDCs' ability to mimic or interfere with an organism's natural hormone function.

Chemical Uptake: Fish and other aquatic creatures that consume microplastics may absorb the leached chemicals into their tissues. Changes in hormone levels may result from the absorbed chemicals interfering with the endocrine system's regular operation.

Hormonal pathway distruption: In fish and other aquatic creatures, the endocrine system is in charge of controlling a number of essential functions, such as growth, development, metabolism, and reproduction.

Mimicking Natural Hormones: A few of the EDCs discovered in microplastics have the structural similarity to natural hormones like testosterone or estrogen. These artificial substances have the ability to attach to hormone receptors and cause undesirable reactions, such as early spawning or changed sex ratios.

Blocking Hormone Receptors: In certain situations, EDCs can prevent hormones that naturally occur from attaching to their receptors. This may stop some biological processes from activating normally, which could result in problems including stunted growth or decreased fertility.

Effects on Reproductive Health: Reduced egg and sperm quality can result from hormonal disruption of the gametogenesis process, which produces eggs and sperm. Lower rates of fertilization and decreased embryo viability may arise from this. According to various research, fish populations' sex ratios can be skewed by exposure to EDCs from microplastics since it can lead to a greater prevalence of one sex over the other. Long-term effects on biodiversity and population stability may result from this. Reproductive cycles can be impacted by hormonal abnormalities. Fish may spawn in response to disturbances too early, too late, or not at all. This may lessen the likelihood of successful reproduction, particularly in species whose spawning is dependent on particular environmental cues.

Long-Term Population Effects

Decreased Reproductive Success: Populations exposed to microplastics may see a decrease in reproductive success over time, which could result in population decreases. For species that are already under risk from overfishing, habitat loss, or climate change, this is especially alarming.

Developmental Abnormalities: Children that are exposed to microplastics in the womb or in their early stages of development may have developmental abnormalities that affect their ability to procreate, such as malformed gonads or changed hormone levels.

Impacts on the Ecosystem: Because these species may be crucial to the functioning of food webs and ecosystems, disturbances to their reproductive processes may have wider effects on the ecosystem.

Effects on aquatic organism

Sussarellu *et al.,* (2016)'s findings are noteworthy because they offer a new paradigm that suggests MPs reduce reproductive output via altering organism energy and food allocation. Sussarellu *et al.,* (2016) investigated the effects of two months of exposure to PS-MP on the reproduction of adult Crassostrea gigas oysters and their progeny before they spawned. In exposed oysters, there was a decrease in sperm swimming speed, fertility, and gamete and oocyte quality. These consequences

slowed the growth of their larval progeny and had a considerable impact on the quality of the offspring. Significantly, they saw a drop in sperm velocity (-23%), oocyte diameter (-5%), and oocyte number (-38%) in oysters exposed to PS-MPs. These findings may have an effect on larval survival and progeny development.

Long-term exposure to MPs has been shown to have a deleterious effect on the fertility of the marine copepod *Calanus helgolandicus*, resulting in a decrease in hatching success (Cole *et al.,* 2015).

Martínez-Gomez *et al.,* (2017) investigated the possible impact of MPs exposure on sea urchin fertilization (*Paracentrotus lividus*), and they found substantial reductions in fertilization success rates after MP exposure. Sex hormone levels in the plasma of female fish have significantly decreased as a result of ingesting microplastic. In contrast, male fish exposed to microplastics have elevated levels of testosterone and 17β estradiol (Brander *et al.,* 2016). It appears that the impact of microplastics on fish sex hormones varies depending on the sex. The evidence that is currently available, however restricted to a small number of studies, is consistent with the theory that MP exposure causes a broad range of harmful effects that may affect the ability to reproduce.

Conclusion

Plastic is an invaluable and useful material that is utilized to make the majority of items in our daily lives. However, in the modern world, improper use, management, and handling of plastics have resulted in pollution, contaminating plastics throughout the aquatic ecosystem. The act of discarding plastic waste into the ocean puts marine life, including plankton and marine mammals, aquatic resources, and humans, in grave danger. These ubiquitous microplastic particles have been shown to harm fish's gastrointestinal tract, neurological system, reproductive system, gills, endocrine system, and liver in addition to interfering with their regular metabolic activities. The simplest and most considerate ways to lessen microplastic contamination are to limit overuse, raise people's awareness and encourage behavioural changes, enhance waste segregation technology, boost recycling volume, and repurpose plastic trash. By implementing appropriate waste management techniques, extending the shelf life of plastic products, and raising public awareness, the discharge of plastic litter into ecosystems can be significantly decreased, leading to the restoration of the aquatic ecosystem.

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MINI TRACTOR OPERATED GARBAGE COLLECTOR

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Abstract
Leaves scattered on the parks, passages, and other places have a detrimental effect on the beauty of the environment, and decrease photosynthesis, hence, the efficiency of plants. Leaves are also used in the production of peat. This makes using leaves collectors in parks, and organizations with a green space useful. Due to the fact that leaves take up a high volume, their transportation is difficult. Using the machine introduced in this paper which was equipped with a suction-blower system, increases efficiency, and at the same time decreases the costs of green space, and their workforce cost. Focusing on overcoming the mentioned difficulties, this study was carried out in order to design and produce a tractor powered leaves collector equipped with suction-blower system.

Introduction
As urban greening initiatives expand, the amount of vegetation in cities is on the rise. In places like campuses, parks, and residential communities, lawns often accumulate fallen leaves and household waste. This not only harms the grass but also diminishes the aesthetic appeal of these areas. Currently, most lawn maintenance is performed by sanitation workers, which can impact their health and is not sustainable for modern urbanization. To address these issues, the development and implementation of mechanized cleaning solutions could be a key step forward. Professional cleaning equipment, such as automated lawn sweepers or robotic cleaners, could efficiently manage debris on lawns, ensuring that the grass remains healthy and the environment aesthetically pleasing. This would reduce the reliance on manual labor, enhance worker safety, and align with the trend toward more technologically advanced and sustainable urban management practices.

Development of garbage collector
To overcome these challenges, the focus should shift towards mechanization, with the goal of replacing manual labor a mini Tractor operated garbage collector has been developed in the Department of Farm Machinery & Power Engineering, Agricultural Engineering College and Research Institute, Coimbatore for collecting the dry leaf litters in the lawn, roadside etc., The garbage collecting machine is an attachment to the mini tractor which requires two operators (one person to drive tractor and another person to hold the suction pipe for collection of garbages) to perform the operation of collecting the leaf litters and garbages. The main frame is of size (1000 x 680 mm) fabricated with square tube of size (40 x 40 mm) with the thickness of 3mm. The three point hitch frame was developed in such a way that it can be adjusted from minimum 300 mm to maximum of 900mm to suit any tractor.

The power from the mini tractor engine of 15- 25 hp and 540 rev/min rotational speed from PTO is transmitted with PTO shaft to the gear box with the speed ratio of 1:2 and then to vaccum blower.

From the gear box power is transmitted to the vaccum blower through “V” belt pulley arrangement for rotation of blower to create the high vaccum pressure for collecting the garbage and transfers to the collecting bin which is fixed to the backside of the garbage collector. The vaccum blower speed is increased by using a driving pulley of 200 mm diameter and a driven pulley of 50 mm diameter. The rotational speed available for the vaccum blower for collecting the leaf litters is 4200 rev/min and 8200 rev/min in standard PTO speeds of 540 & 1000 rev/min.

The blower with ten impellers was selected to transport, accelerate and compress the air on the momentum principle. A vacuum is created at the suction end and the compressed air (exhaust air) escapes through the outlet opening. During the suction, the leaf debris are sucked and passed through exhaust outlet to the collecting bin. It is cost effective and easy operating mechanism compared to other leaf collecting instruments and machines. In autumn season a greater number of leaves are found to be in roadways, pathways and garden, by using this simple application we can easily remove the leaves from the ground thereby reducing the human effort and time.

View of the Garbage collector attached to the mini tractor

Operational view of the garbage collector

Conclusion

The field capacity of garbage collector is 0.08 ha/h with the field efficiency of 89 per cent. The cost of mini tractor operated garbage collector is Rs. 26,000 (excluding mini tractor). The cost operation of mini tractor operated garbage collector is 1610/ha whereas the cost of operation with manual collecting of garbage's is Rs 3500/ha. The mini tractor operated garbage collector resulted in 55 per cent saving in cost and 86 per cent savings in time when compared to manual collection of garbage's besides increasing the annual usage of mini tractor

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MISCONCEPTIONS DURING PREGNANCY

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Abstract
This article delves into prevalent misconceptions surrounding pregnancy, addressing a wide range of topics including nutrition, exercise, medication use, fetal development, and lifestyle choices. By examining current scientific evidence, we aim to dispel myths and provide expectant mothers with reliable information to support healthy pregnancies. The article highlights the importance of evidence-based knowledge in prenatal care, emphasizing the role of healthcare providers in educating and guiding pregnant women. Through a comprehensive review of common beliefs and their scientific basis, this chapter serves as a valuable resource for both healthcare professionals and expectant mothers in navigating the complex landscape of pregnancy-related information. We explore how these misconceptions can impact maternal and fetal health, and provide evidence-based recommendations for optimal prenatal care. The chapter also addresses the origins of these myths and discusses strategies for effective communication of accurate information to pregnant women.

Introduction
Pregnancy is a transformative experience that brings joy, anticipation, and often, a fair share of anxiety. As expectant mothers navigate this new terrain, they are bombarded with advice from various sources, including friends, family, the internet, and sometimes even well-meaning strangers. While much of this information is helpful, a significant portion consists of outdated beliefs, cultural myths, or misinterpreted facts. These misconceptions can lead to unnecessary worry, inappropriate behaviors, or even potential harm to the mother or fetus if not addressed properly. The importance of accurate information during pregnancy cannot be overstated. Misconceptions can influence a woman's decisions regarding prenatal care, lifestyle choices, and preparation for childbirth. Moreover, in an age where information is readily available at our fingertips, distinguishing between fact and fiction has become increasingly challenging (Anonymous, 2009). The article aims to address some of the most prevalent misconceptions surrounding pregnancy, providing evidence-based information to help expectant mothers make informed decisions about their health and the health of their unborn children.

The origins of pregnancy myths are diverse and complex. Some stem from cultural traditions passed down through generations, while others arise from misinterpretations of scientific studies or outdated medical advice. In some cases, these myths may have had a basis in past medical practices that have since been disproven or refined. Understanding the sources of these misconceptions is crucial for effectively addressing and dispelling them. Healthcare providers play a pivotal role in combating misinformation. They are often the first line of defense against pregnancy myths and must be equipped with the latest evidence-based knowledge to guide their patients (Anonymous, 2013).

By examining common myths and presenting current scientific understanding, we hope to empower both healthcare providers and pregnant women with the knowledge needed to navigate the

complexities of prenatal care. Understanding and dispelling these misconceptions is crucial for promoting optimal maternal and fetal health outcomes, reducing unnecessary anxiety, and ensuring that pregnant women make informed decisions throughout their pregnancy journey.

Common Misconceptions

a) Eating for Two

One of the most pervasive myths surrounding pregnancy is the notion of "eating for two." This misconception often leads women to believe they need to significantly increase their caloric intake throughout pregnancy. However, research shows that the additional energy requirements during pregnancy are much more modest than commonly believed. In reality, during the first trimester, there is typically no need for additional calories. The second and third trimesters require only about 340 and 450 extra calories per day, respectively. Overeating during pregnancy can lead to excessive weight gain, which is associated with various complications such as gestational diabetes, hypertension, and difficulties during labor and delivery (Anonymous, 2009). Healthcare providers should emphasize the importance of a balanced diet rich in essential nutrients rather than focusing solely on increased caloric intake. Educating women about appropriate weight gain based on their pre-pregnancy BMI is crucial for promoting optimal maternal and fetal health.

Instead of simply eating more, pregnant women should focus on consuming nutrient-dense foods that provide essential vitamins and minerals crucial for fetal development. Key nutrients to focus on include:

- **Folic acid**: Critical for preventing neural tube defects
- **Iron:** Essential for preventing anemia and supporting the increased blood volume during pregnancy
- **Calcium:** Necessary for fetal bone development
- **Omega-3 fatty acids:** Important for fetal brain and eye development

b) Avoiding Exercise

Another common misconception is that pregnant women should avoid exercise to protect the fetus. Contrary to this belief, regular physical activity during pregnancy offers numerous benefits for both mother and child, provided there are no medical contraindications (Dipietro et al., 2019). Moderate exercise during pregnancy can help manage weight gain, reduce the risk of gestational diabetes and preeclampsia, improve mood and sleep quality, and potentially ease labor and delivery (Davenport et al., 2018). The American College of Obstetricians and Gynecologists recommends at least 150 minutes of moderate-intensity aerobic activity per week for pregnant women (Anonymous, 2020).

It’s crucial to educate women about listening to their bodies, staying hydrated, and avoiding overexertion. It's important to note that while exercise is generally safe, certain activities should be avoided, such as contact sports or those with a high risk of falling. Tailoring exercise recommendations to each woman’s fitness level and pregnancy stage can help ensure safe and beneficial physical activity throughout pregnancy.

c) All Medications Are Harmful

The belief that all medications should be avoided during pregnancy is a misconception that can potentially harm both mother and fetus. While it's true that some medications can pose risks during pregnancy, many are safe and sometimes necessary for managing chronic conditions or pregnancy-

related symptoms (Lupattelli et al., 2014). Discontinuing essential medications without medical advice can lead to serious health consequences. For instance, untreated depression during pregnancy is associated with poor outcomes for both mother and child (Grigoriadis et al., 2013). Similarly, poorly controlled asthma or hypertension can pose significant risks to fetal development and maternal health (Murphy et al., 2011).

It's crucial for healthcare providers to stay updated on the latest research regarding medication safety during pregnancy. The FDA pregnancy risk categories have been replaced with more descriptive labeling to help guide decision-making. Pregnant women should be encouraged to discuss all medications, including over-the-counter drugs and supplements, with their healthcare provider.

d) Caffeine Must Be Completely Avoided

The complete avoidance of caffeine during pregnancy is a common misconception. While high caffeine intake has been associated with increased risk of miscarriage and low birth weight, moderate consumption is generally considered safe (Chen et al., 2014). Current guidelines suggest limiting caffeine intake to 200 mg per day during pregnancy, which is equivalent to about one 12-ounce cup of coffee (Anonymous, 2010). It's important to note that caffeine is found not only in coffee but also in tea, chocolate, and some soft drinks.

e) Pregnancy Cravings Indicate Nutritional Needs

A popular belief is that pregnancy cravings are the body's way of signalling nutritional deficiencies. While cravings are common during pregnancy, affecting up to 60-90% of pregnant women, there is limited scientific evidence to support the idea that they directly correspond to specific nutritional needs (Orloff and Hormes, 2014)). Cravings during pregnancy are thought to be influenced by hormonal changes, cultural factors, and psychological needs rather than nutritional deficiencies. Some cravings, particularly those for non-food items (a condition known as pica), may indicate nutritional deficiencies, but this is not the case for most common food cravings (Young, 2010). While it's generally fine to indulge in cravings in moderation, mothers should be encouraged to make healthy food choices that meet their nutritional needs during pregnancy.

Conclusion

Through a comprehensive examination of myths related to nutrition, exercise, medication use, caffeine consumption, and cravings, we have unravelled the significance of accurate knowledge in promoting maternal and fetal health. The dispelling of these misconceptions is crucial for healthcare providers to effectively counsel and support pregnant women throughout their journey. Despite the wealth of information available, many misconceptions persist, highlighting the need for continued education and research in the field of prenatal care. Healthcare providers play a crucial role in disseminating accurate information and should stay updated on the latest evidence-based guidelines. Efforts should be made to conduct more research work to address gaps in knowledge and to develop effective strategies for communicating accurate information to expectant mothers.

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MORINGA- ANCIENT WISDOM FOR MODERN HEALTH

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Abstract
Moringa oleifera is universally referred to as the miracle plant or the tree of life. The Moringa plant derives this name based on its uses, particularly with regard to medicine and nutrition. It is a plant native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. Moringa oleifera belonging to the family of *Moringaceae* which is an effective remedy for malnutrition. Moringa is rich in nutrition owing to the presence of a variety of essential phytochemicals present in its leaves, pods and seeds.

Introduction
Moringa oleifera the "miracle tree" thrives globally in almost all tropical and subtropical regions, but it is believed to be native to Afghanistan, Bangladesh, India, and Pakistan. The Moringa family comprises 13 species (*M. oleifera*, *M. arborea*, *M. rivae*, *M. ruspoliana*, *M. drouhardii*, *M. hildebrandtii*, *M. concanensis*, *M. borziana*, *M. longituba*, *M. pygmaea*, *M. ovalifolia*, *M. peregrina*, *M. stenopetala*), of which *M. oleifera* has become well known for its use in nutrition. Moringa has the unique property of tolerating drought therefore it is evergreen deciduous tree that usually grows up to 10-12 m in height.

Moringa is also known as 'The Tree of Life' and has been an essential part of Ayurvedic tradition on the Indian subcontinent for thousands of years, where it has been mentioned as a cure for over 300 diseases. On the battlefields of ancient India, Moringa extract (with its antiseptic and anti-inflammatory properties) was frequently administered to iron-age Mauryan soldiers, who believed that by taking it they'd have the stamina to fight. It was also thought to take away the stress of combat and relieve the pain from their wounds. Moringa, now touted as a superfood and celebrated by western countries, has been an integral part of the Indian diet for ages.

Morphology
Leaves are bipinnate or more commonly tripinnate up to 45 cm long. These are compound leaves with leaflets 1-2 cm long. The fragrant bisexual, yellowish, white flowers are borne on slender, heavily stalks in spreading or drooping axillary cluster 10-25 cm long. Fruits are trilobed capsules and are frequently referred to as pods. Seed are round with a brownish semi permeable seed hull, with 3 papery wings. Seedlings develop a swollen, tuberous, white taproot, which has a characteristics pungent odor, and very sparse lateral roots. The bark is whitish grey, thick soft, fissured and warty or corky, becoming rough.

Nutritional value
Nearly all parts of the tree are used for their essential nutrients. *M. oleifera* leaves have a high content of beta-carotene, minerals, calcium, and potassium. Dried leaves have an oleic acid content of about 70%, which makes them suitable for making moisturizers. The powdered leaves are used to make many beverages, of which "Zija" is the most popular in India. The bark of the tree is considered very useful in the treatment of different disorders such as ulcers, toothache, and

hypertension. Roots, however, are found to have a role in the treatment of toothache, helminthiasis, and paralysis. The flowers are used to treat ulcers, enlarged spleen, and to produce aphrodisiac substances. Moringa leaves also have a low calorific value and can be used in the diet of the obese. The pods are fibrous and are valuable to treat digestive problems and thwart colon cancer. A research shows that immature pods contain around 46.78% fiber and around 20.66% protein content. Pods have 30% of amino acid content. The immature pods and flowers showed similar amounts of palmitic, linolenic, linoleic and oleic acids. The tree is believed to have incredible properties in treating malnutrition in infants and lactating mothers.

Methods of Moringa Preservation

Moringa can be preserved for a long time without loss of nutrients. Drying or freezing can be done store the leaves Preservation by dehydration improves the shelf life of Moringa without change in nutritional value. An overdose of moringa may cause high accumulation of iron. High iron can cause gastrointestinal distress and hemochromatosis. Hence, a daily dose of 70g of moringa is suggested to be good and prevents over accumulation of nutrients.

Socio-economic importance

M. oleifera is mostly used tropical tree. The propagation of tree by both sexual and asexual means is easy and its low demand for soil nutrients and water after being planted makes its production and management easier. Its introduction in farm could be beneficial for both the owner as well as surrounding eco system. *M. oleifera* known was well known to the ancient world but only recently it has been rediscovered as a multipurpose tree with tremendous variety of potential uses. Moringa seeds are used as to extract the oil called Ben oil. The tap roots are used as a spice.

Health Benefits

M. oleifera is often referred as a panacea and can be used to cure more than 300 diseases. Moringa has long been used in herbal medicine by Indians and Africans. The presence of phytochemicals makes it a good medicinal agent. Moringa is very rich is nutrients and it is very helpful to prevent the diseases. Anti diabetic: Several studies have shown that, moringa can act as an anti-diabetic agent. Diabetes leads to several complications such as retinopathy, nephropathy and atherosclerosis etc. Moringa can be used to prevent such ailments.

Anti-cancer activity: M. oleifera can be used as an anticancer agent as it is natural, reliable and safe, at established con- centrations. Studies have shown that moringa can be used as an anti-neoproliferative agent, thereby inhibiting the growth of cancer cells.

Anti-microbial agent: Microbial diseases are widespread and there is a need for antimicrobial agents, M. oleifera has been proven as a good antimicrobial agent.

Hepatoprotective activity: Moringa oleifera leaves are very nutritious. The chemical constituents of leaves like ethanolic extract of leaves have hepatoprotective activity.

Anti-fertility activity: Aqueous extract of Moringa oleifera was found to be effective as anti fertility in presence as well as absence of oestradiol dipropionate and progesterone and shown increased histoarchitecture of uterine.

Immunomodulatory Activity*:* Methanolic extract of the plant contains active constituents such as isothiocyanate and glycoside cyanide, which exhibit immunostimulatory activity and effectively enhance immunity. The recent review paper suggests that various bioactive compounds have been

used to treat various immune-related disorders such as cancer, hypertension, and diabetes, thereby enhancing host immunity.

Conclusion

Moringa oleifera leaves, flowers, stems, roots, pods or other plant organs exhibit a wide kind of pharmacological and physiological activities. It is a tree with diverse potentialities that can be consumed as food or process into other forms to be used in different areas. There is need to study the standardized extracts of M. oleifera components to be used in wide range of areas. This study would serve as the background for future studies.

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MAGNESIUM DEFICIENCY IS A GROWING PROBLEM IN INDIA

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Abstract

The productivity of crops is fairly dependent on the availability of nutrients and efficient use. However, Magnesium (Mg) nutrition of plants is frequently overlooked and shortages will adversely impact plant growth. Many essential plant functions require adequate Mg supplies, the most visible being its role in root formation, chlorophyll, and photosynthesis. Many less visible reactions are also dependent on an adequate supply of Mg. Mg plays a role in several physiological processes that support plant growth and development. However, it has been largely forgotten in fertilization management strategies to increase crop production, which leads to severe reductions in plant growth and yield. This paper briefly summarizes some of the essential roles of Mg for plants and deficiency symptoms and, preventive and corrective measures of Mg deficiency.

Introduction

Despite the well-known role of Mg for various critical functions, there is surprisingly little research activity on the role of Mg nutrition in crop production and quality. Hence, Mg is oftenconsidered a "forgotten element". However, Mg deficiency isincreasingly becoming an important limiting factor in intensivecrop production systems, especially in soils fertilized only withN, P, and K. In particular, Mg depletion in soils is a growing concern for high-productivity agriculture. Mg deficiency is a common nutritional disorder in plants and a widespread problem affecting crop productivity and quality. About 90%–98% of the soil Mg is combined in the crystal lattice structure of minerals and not directly available to plants. The only existing form of Mg for uptake is Mg^{2+}, which has the lowest ionic radius and the biggest hydrated radius among different cations. This unique chemical property creates a weak bond between Mg^{2+} and negatively charged soil colloids as well as root cell borders, which favor the deficiency of interchangeable Mg from the soil.

Magnesium: an essential plant nutrient

Magnesium (Mg) is an essential nutrient that plays a vital role in the growth and development of plants. It is required in relatively large amounts and is considered a macronutrient along with nitrogen, phosphorus, potassium, calcium and sulphur. Mg is involved in many key plant processes, including photosynthesis, respiration and the synthesis of nucleic acids and proteins. In plants Mg is found primarily in the chlorophyll molecule. It is responsible for capturing light energy and converting it into chemical energy through photosynthesis. Without sufficient Mg, plants cannot produce enough chlorophyll. It results in yellowing of leaves and stunted growth. It also plays a critical role in the synthesis of adenosine triphosphate (ATP). It is the primary energy currency of living cells. ATP is required for many cellular processes. It including the conversion of carbon dioxide into organic compounds during photosynthesis. Without enough Mg, plants cannot produce enough ATP. The Mg is also involved in the metabolism of other nutrients. It including calcium, phosphorus and potassium. It helps to activate enzymes that are necessary for the uptake and

utilization of these nutrients. Mg also helps to maintain the pH balance of the soil. It is important for nutrient availability and uptake. This is a critical nutrient for the growth and development of plants. It is required for many key processes including photosynthesis, respiration and the synthesis of nucleic acids and proteins.

FUNCTIONS OF MAGNESIUM IN PLANT GROWTH

The role of Mg is vital to plant growth and health. Mg is the powerhouse behind photosynthesis in plants. Without Mg, chlorophyll cannot capture sun energy needed for photosynthesis. In short, Mg is required to give leaves their green colour. Mg in plants is located in the enzymes, in the heart of the chlorophyll molecule. Mg is also used by plants for the metabolism of carbohydrates and in the cell membrane stabilization. It is also a part of ring structure of chlorophyll molecule (**Figure 1**).

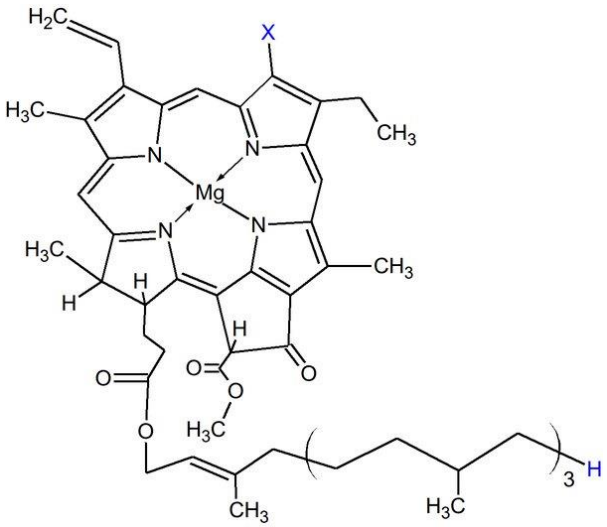

Figure 1. Structural formula of Mg

Physiological and morphological growth-dependent Mg functions in plants are displayed in **Figure 2**.

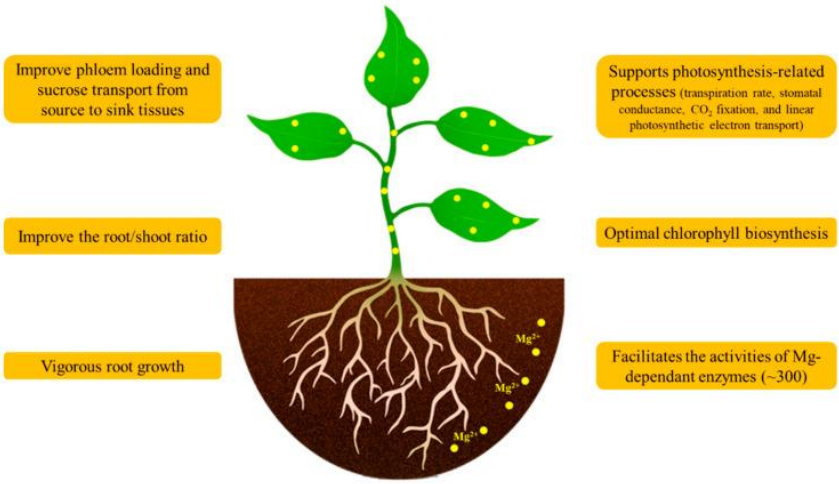

Figure 2. Physiological and morphological growth-dependent Mg functions in plants

Magnesium has specific role in the activation of enzyme involved in respiration, photosynthesis and the synthesis of DNA & RNA. Here are some key functions of Mg in plant growth:

1. Chlorophyll synthesis: Mg is a central component of the chlorophyll molecule, which is responsible for the green colour in plants and is crucial for photosynthesis. Without sufficient Mg, plants cannot produce chlorophyll, leading to chlorosis (yellowing of leaves) and reduced photosynthetic efficiency.
2. Photosynthesis: Photosynthesis is the process by which plants convert light energy into chemical energy, producing sugars that are essential for growth and development. Mg is involved in the activation of enzymes that are essential for photosynthesis, such as ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco).
3. Energy transfer: Mg plays a role in the transfer of phosphate groups in ATP (adenosine triphosphate), the energy currency of cells. ATP is essential for various metabolic processes in plants, including nutrient uptake, synthesis of organic compounds, and cell division.
4. Stabilization of nucleic acids: Mg stabilizes the structure of nucleic acids (DNA and RNA) in plant cells, playing a role in gene expression, protein synthesis, and overall plant growth and development.
5. Enzyme activation: Mg is a cofactor for many enzymes involved in metabolic processes within plants. These enzymes are essential for various functions, including nutrient uptake, carbohydrate metabolism, and cell division.
6. Regulation of ion transport: Mg plays a role in the regulation of ion transport across cell membranes in plants, helping to maintain osmotic balance and nutrient uptake.

Role of magnesium in plant reproduction

Magnesium plays a vital role in various aspects of plant reproduction, including pollen germination and tube growth, seed and fruit development, flower formation, pollen-pistil interactions, and fertility. Ensuring sufficient Mg availability is crucial for optimizing plant reproductive success. Here are some of the key ways in which Mg is involved in plant reproductive processes:

Pollen germination and tube growth: Mg is required for the germination of pollen grains and the subsequent growth of pollen tubes, which are essential for successful fertilization. Mg helps regulate the osmotic potential and ionic balance within pollen tubes, facilitating their elongation and guidance towards the ovule.

Seed and fruit development: Mg is important for the proper development of seeds and fruits. It is involved in the biosynthesis of important biomolecules, such as nucleic acids and proteins, which are crucial for seed and fruit maturation. Mg also plays a role in the mobilization and translocation of nutrients to developing seeds and fruits, supporting their growth and quality.

Flower development: Mg is involved in the formation and development of floral structures, including sepals, petals, stamens, and pistils. It helps regulate the expression of genes related to flower development and the production of essential plant hormones, such as auxins and cytokinin, which are crucial for flower initiation and growth.

Pollen-pistil interactions: Mg is required for the proper functioning of the pistil, the female reproductive organ of the flower, in recognizing and accepting compatible pollen grains. It helps maintain the optimal ionic environment for pollen tube growth and guidance towards the ovule, facilitating successful fertilization.

Fertility and seed production: Adequate Mg levels in plants are associated with increased fertility and seed production, as it supports the development and viability of both male and female reproductive structures. Mg deficiency can lead to reduced pollen production, decreased pollen viability, and impaired seed set, ultimately affecting the overall reproductive success of the plant.

Magnesium in the soil

Magnesium is abundant in the earth's crust. It is found in a wide variety of minerals. Magnesium becomes available for plant use as these minerals weather or break down. The majority of the soils in western Minnesota have naturally high levels of Mg. For the acid soils of the eastern counties, the addition of dolomitic limestone in the crop rotation, when needed, should supply adequate Mg for crop growth. Magnesium is held on the surface of clay and organic matter particles. Although this exchangeable form of Mg is available to plants, this nutrient will not readily leach from soils. The general relationship between forms of Mg in the soil is illustrated in **Figure 3**.

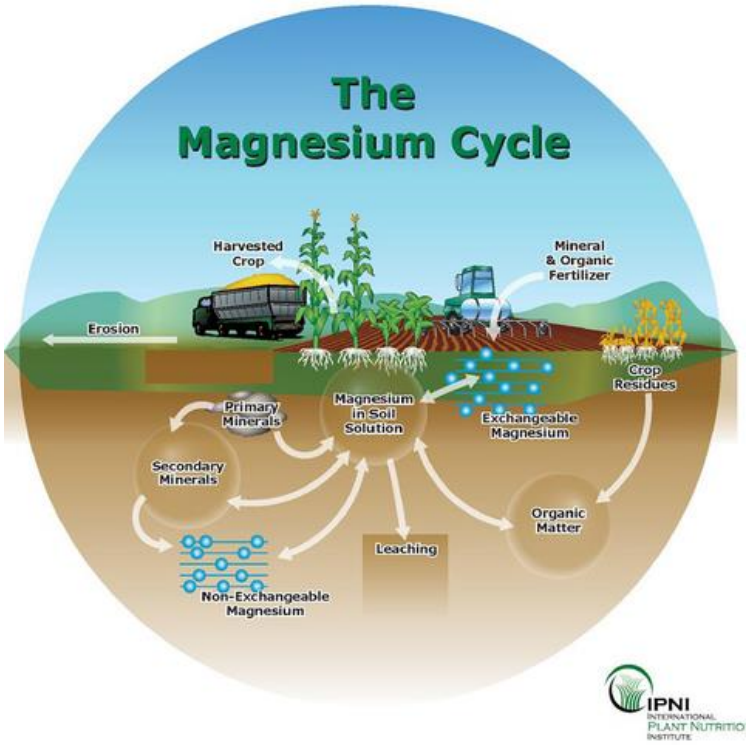

Figure 3. Generalized soil magnesium cycle representing Mg in the soil and where Mg may be applied or removed on an annual basis

Causes of Mg deficiency

Mg deficiency is a common nutritional disorder in plants that inhibits plant growth and development and eventually affects the yield and quality. Mg scarcity is becoming an important concern in an intensive cropping system in which the soils are only fertilized with N, P, and K. It is also a critical issue in highly weathered soils, where it is subjected to potential leaching and interaction with aluminium (Al). Since Mg has a large hydrated radius, it is weakly absorbed by highly weathered, acidic, and coarse soils. Therefore, these soils are found to be Mg deficit soils due to excess leaching of Mg nutrient, specifically in acidic soil with low cation exchange capacity. In soils with limited fertility, leaching of Mg can be as high as 25 kg ha−1, while it can be increased up

to 40–70 kg ha−1, depending upon numerous variables such as soil and crop type, environmental conditions, and drainage volume.

The availability of Mg2+ to plants depends on various factors: distribution and chemical properties of source rock material, and its grade of weathering and site-specific climatic and anthropogenic factors. Mg2+ is exceptionally sensitive to discharging, which is considered as a crucial factor affecting Mg2+ availability for roots. Mg2+ leaching occurs usually in acidic soils (pH < 4.5, high H+/proton) with reduced cation-exchange capacity, and about 70% of the arable land on Earth is acidic. MgCO3 development and excess accumulation of Ca2+, K+, and Na+ in soluble soils likewise decreases Mg2+ accessibility to crops. Drought affected soil and some Al toxic soils likewise hinder Mg2+ retention by roots. Among a few contending elements in soils, such as K, Ca, Al, and NH4, Mg2+ is the least taken-up nutrient. Raised temperature and high precipitation in tropical areas also lead to Mg2+ leaching and lessens the balance between plant Mg2+ concentration and Mg2+ availability. Moreover, acidic soils impede Mg2+ uptake in plants by allowing higher leaching rates of Mg2+ and higher concentrations of Al and Mn. In calcareous soils, the existence of Ca and bicarbonates (HCO3−) in higher aggregates affects the uptake of Mg and results in Mg depletion, whereas in alkaline soils, Mg availability is reduced due to the formation of magnesium carbonate and gypsum. The excessive application of K and ammonium (NH4+), especially in sandy soils, often increases the chances of Mg scarcity. Under Mg-deficient conditions, other nutrients (Ca, K) have strong antagonistic uptake behaviour, which results in relative or absolute excess of Ca2+, H+, NH4+, and Al3+.

Symptom of Mg deficiency in Plants

In view of diverse functions of Mg in plants, a questionarises as to which function or structure is affected first underMg deficiency. The most common answer is chlorophyll level,or photosynthesis, or protein synthesis. When it will be inadequate, plants will exhibit characteristic symptoms of Mg deficiency. A characteristic symptom of Mg deficiency is chlorosis between the leaf veins, and around the edges occurring first in the older leaves because of the mobility of this element. Due to the fair mobility of elements, plants remobilize Mg from older leaves to younger leaves; that is the reason why the first visual deficiency symptoms usually appear on older leaves and then on newly expanded leaves. Purple, red, or brown color may also appear on the leaves. Eventually, if left unchecked, the leaf and the plant will die. An additional symptom of Mg deficiency may be pre mature leaf abscission.

The appearance of Mg deficiency symptoms is highly dependent on light intensity. High light intensity increases the development of interveinal chlorosis, together with some reddish spots on the leaf blade. Therefore, the well-documented differences between plant species in the expression of visual Mg deficiency symptoms and also in critical deficiency concentrations of Mg in the leaf tissue may be related to the light intensity in a particular growth environment. The leaf damage that occurs in Mg-deficient plants exposed to high light intensity has been ascribed to enhanced generation of damaging highly reactive oxygen species in chloroplasts at the expense of inhibited photosynthetic CO_2 fixation. Plants growing under conditions of high light intensity appear to have a higher requirement for Mg than the plants grown under lower light intensity. The visibility of symptoms is also often related to the amount of light the leaves or plant is exposed to. Plant or leaves exposed to high light intensity will show more symptoms than others**.** Normally, Mg concentration under 1–2 mg g^{-1} dry leaf weight is related to the initiation of chlorosis. The characteristic symptoms of Mg deficiency in different crops are being given in Figures 4, 5, 6, 7, 8,

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9 and 10.

Figure 4. Magnesium deficiency in Maize. The striping extends the full length of the leaf

Figure 5. Magnesium deficiency in Citrus

Figure 6. Magnesium deficiency symptoms in potatoes.
The loss of colour begins at the tips of the lower leaves.

Figure 7. Magnesium deficiency in tobacco

Figure8. Magnesium deficiency in Cucurbits

Figure 9. Magnesium deficiency in Strawberry

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Figure 10. Magnesium deficiency in Citrus

Prevention and Correction of Mg Deficiency

For maximum or optimal economic yield, farmers should ensure the adequate Mg supply, which at the same time will ensure optimal crop quality in virtually all cases. Sometimes there are not enough mineral nutrients in soil and it is necessary to fertilize in order to replenish these elements and provide additional Mg for plants. To prevent Mg deficiency, it is important to maintain proper soil pH and to provide adequate fertilization and management practices. Soil application of Mg @15-25 kg/ha is needed to take care of optimum supply of the nutrient to the crops. In standing crops, foliar application of $MgSO_4$ @ 1.0% at critical growth stages, for example, flower initiation, boll formation and boll development stages in cotton, branching and pre-flowering stage in pulses and oilseeds, at tillering and panicle initiation/flag leaf stage in rice, wheat and barley etc., knee high stage and before ear emergence or tasselling stages in pearl millet, sorghum and maize. Because foliar sprays have no residual effect and fresh applications must be made to each crop. Moreover, the amount depends upon the crop and soil nutrient status.

The application of dolomitic limestone is the most cost effective method for applying the Mg that is needed. The Mg content of dolomitic limestone varies from 8-10%. To be effective, this Mg source should be broadcast and incorporated before planting. There are fertilizers that are a combination of potassium sulphate and magnesium sulphate. The Mg content is 11 percent. The sulfur (S) concentration is 22 percent and the K_2O percentage is 22 percent. This fertilizer is easily used in a starter fertilizer for corn or as a Mg source when there is no desire to increase soil pH. Irrigation water can contain a substantial amount of Mg^{2+} which is readily available to a crop. Poly 4 is a product containing K, Mg, Ca and S which be used to correct Mg deficiency apart from K, Ca and S. Magnesium should be applied to soils with dolomitic limestone (Hi-Mag lime). Sulphate of potash and magnesia (K-Mag, Sul-Po-Mag) is a naturally mined mineral deposit that can also be applied to add magnesium to soils. Other magnesium sources include magnesium sulphate (same as Epson Salts), magnesium oxide (basic slag), and magnesium chloride. To correct a deficiency in growing crops, soluble magnesium sources should be used.

Summary

Although the need for the addition of Mg to a fertilizer program is not widespread in India, this nutrient can increase crop production when needed. The potential for need should not be ignored. If there is doubt about the need, get the soil tested for available Mg to be sure about.

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SOIL NUTRIENT MANAGEMENT IN ORGANIC FARMING

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Introduction

Soil nutrient management is a critical component of organic farming. It involves maintaining and enhancing soil fertility using natural methods to ensure optimal plant growth and crop productivity. Unlike conventional farming, which relies heavily on synthetic fertilizers, organic farming focuses on sustainable practices that promote the natural cycling of nutrients. Effective soil nutrient management is essential for maintaining soil health, supporting plant nutrition, and enhancing the overall resilience of the farming system.

Fundamental Principles of Soil Nutrient Management

The primary principle of soil nutrient management in organic farming is to maintain or improve soil fertility over the long term. This involves a deep understanding of the soil's biological, chemical, and physical properties. Organic farming relies on organic matter, such as compost, green manure, and crop residues, to supply nutrients and improve soil structure. These materials not only provide essential nutrients like nitrogen, phosphorus, and potassium but also enhance soil organic matter, which improves water retention, aeration, and microbial activity.

Another principle is the promotion of natural nutrient cycles. Organic farming practices are designed to enhance the natural processes that cycle nutrients through the soil. This includes encouraging the activity of soil organisms, such as earthworms, bacteria, and fungi, which decompose organic matter and release nutrients in forms that plants can use. These practices also help to maintain a balance between nutrient inputs and outputs, reducing the risk of nutrient loss through leaching or runoff.

Methods of Soil Nutrient Management in Organic Farming

One of the primary methods used in organic farming is the application of compost. Compost is decomposed organic matter that provides a rich source of nutrients for plants and improves soil structure. It is made from various organic materials, such as crop residues, kitchen waste, animal manure, and leaves. The process of composting involves controlled decomposition, where microorganisms break down the organic material, converting it into a stable, nutrient-rich product. The use of compost enhances the soil's organic matter content, improves moisture retention, and promotes beneficial microbial activity.

Green manuring is another vital practice. Green manures are crops grown specifically to be ploughed back into the soil to improve its fertility and structure. Leguminous green manure crops, such as clover and vetch, are especially beneficial because they can fix atmospheric nitrogen in the soil through a symbiotic relationship with rhizobia bacteria. This process not only adds nitrogen to the soil but also improves soil texture and organic matter content.

Cover cropping is a method where specific crops are grown to cover the soil, providing multiple benefits such as preventing soil erosion, suppressing weeds, and enhancing soil fertility. Cover crops like rye, oats, and buckwheat help retain soil moisture and nutrients while protecting the soil from degradation. Additionally, crop rotation and intercropping are used to manage soil fertility and control pests and diseases. These practices involve growing different crops in succession or simultaneously, which helps in breaking pest and disease cycles and reduces the depletion of specific soil nutrients.

Biological Inputs and Soil Amendments

Organic farming uses biological inputs such as biofertilizers and soil amendments to enhance soil fertility. Biofertilizers are living microorganisms that enhance the availability of nutrients to plants. They include nitrogen-fixing bacteria (Rhizobium, Azotobacter), phosphate-solubilizing bacteria, and mycorrhizal fungi. These organisms colonize the root zone, improving nutrient uptake and promoting plant growth. Soil amendments, such as rock phosphate, gypsum, and lime, are used to correct soil pH, improve structure, and provide essential nutrients.

Conclusion

Soil nutrient management in organic farming is a holistic approach that emphasizes the use of natural methods to maintain and enhance soil fertility. Through the application of compost, green manures, cover crops, crop rotation, and biological inputs, organic farmers create a sustainable system that supports plant nutrition and soil health. These practices not only provide essential nutrients but also improve soil structure, water retention, and microbial activity, contributing to the long-term sustainability of the farming system. By prioritizing natural nutrient cycling and ecological balance, organic farming offers a viable alternative to conventional farming practices.

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PACU FARMING IN INDIA: A COMPREHENSIVE GUIDE TO CULTURING THE AMAZONIAN GIANT FOR SUSTAINABLE AQUACULTURE

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Introduction

Piaractus brachypomus, commonly known as pacu, is a freshwater fish species native to South America, particularly the Amazon River Basin. Known for its fast growth rate, adaptability to various environmental conditions, and high consumer demand, pacu has gained attention in aquaculture ventures globally, including in India.

In recent years, India has seen significant advancements in freshwater aquaculture, driven by the increasing demand for diverse fish species and sustainable farming practices. Pacu, with its robust growth potential and favorable market appeal, presents a promising opportunity for aquaculturists in India. The species' ability to thrive in different water bodies, including ponds and reservoirs, coupled with its omnivorous feeding habits, contributes to its suitability for aquaculture in varied Indian climatic conditions.

The cultivation of *Piaractus brachypomus* in India not only addresses the burgeoning demand for high-quality freshwater fish but also supports efforts towards diversifying the aquaculture industry. By leveraging technological innovations and best practices in fish farming, Indian aquaculturists are exploring the optimal methods to maximize pacu production while ensuring sustainability and environmental responsibility.

Guidelines for streamlining the culture of *Piaractus brachypomus* (pacu) are essential for several reasons:

1. Sustainable Aquaculture Practices: Proper guidelines help ensure that pacu farming adheres to sustainable practices, minimizing environmental impacts such as water pollution, habitat destruction, and overuse of resources. Clear standards promote eco-friendly aquaculture, reducing the risks of harmful practices that could damage local ecosystems.

2. Optimized Growth and Health: Pacu is known for its high growth potential, but this can only be fully realized with optimal conditions. Guidelines on feeding, stocking density, water quality management, and disease prevention help farmers maintain the health of their stock, thereby maximizing growth rates and ensuring high yields.

3. Preventing Invasive Risks: As an introduced species in India, there is always the risk of pacu becoming invasive, potentially outcompeting native species and disrupting local ecosystems. Strict guidelines for containment, handling, and farming practices help mitigate these risks, ensuring pacu culture doesn't harm local biodiversity.

4. Market Demand and Economic Viability: Standardized farming protocols can improve the quality of pacu produced, ensuring consistency in size, taste, and overall market appeal. Guidelines on post-harvest handling, processing, and packaging enable farmers to meet market demands, both locally and internationally, thereby enhancing the economic viability of pacu farming in India.

5. Training and Capacity Building: Well-documented guidelines serve as educational tools for new and existing fish farmers. They offer step-by-step instructions and best practices for pacu culture, empowering farmers with the knowledge and skills necessary to improve production efficiency and profitability.

6. Ensuring Compliance with Regulations: India has regulations governing aquaculture practices to ensure environmental protection and food safety. Clear guidelines help farmers comply with these regulations, reducing legal risks and fostering a more transparent and responsible aquaculture industry.

Streamlining the culture of Pacu, *Piaractus brachypomus*

The important activities for the grow-out culture of commercially important cultivable species including pacu are broadly divided as

i. Pond preparation;
ii. Seed sourcing;
iii. Seed transport and stocking;
iv. Crop management including management of pond environment, nutrition, and health management;
v. Harvesting and
vi. Avoiding escape of cultured pacu to natural water bodies.

Pond Preparation

- Ponds with sandy loom soil having less than 40% sand should be used for grow-out farming of pacu.
- The soil pH should be in the range of 6.5-7.0 which will help in easy maintenance of the pH of the overlying water at 7.0-8.0 range.
- A minimum water depth of 1.5 m should be maintained in the grow-out pond.
- Lime application for soil and water treatment should be done to get the desired pH ranges.
- Since pacu is omnivorous, ensuring the availability of a good plankton population in water not only helps in good water quality but also promotes growth. Therefore, fertilization should be carried out at regular intervals to improve and maintain pond productivity.
- Fertilization should be carried out in the pond one week before seed stocking with basal application of 3 t/ha of cow manure mixed with SSP@ 10 kg/t of cow manure.
- Application of poultry manure at 1.5-2.0 t/ha-m also ensures adequate plankton growth by the time of seed stocking.
- Basal application of cow/poultry manure is skipped when mahua oil cake (@2.5 t/ha) is used as a piscicide

Seed procurement

- The brood stocks used for breeding are reared at a stocking density of 1200-1500 kg/ha, and two to three months before breeding, the fish are fed with special diets having about 25 to 30 % protein.

- For broodstock development, offspring from different families are used.
- Brood fish used in the breeding program are in the 2–5-year class.
- Spawns should not be produced from a single/limited number of parents, and a 1:1 sex ratio is maintained in the breeding pool
- Milt used for fertilizing the eggs should not be pooled as it can lead to gametic competition and one male can fertilize most of the eggs.
- In addition, if possible, 10-25% of new brood fish should be procured in each generation which can help in reducing inbreeding.
- Fingerling of more than 10 g body weight should be used as the minimum size for grow-out stocking.
- The seed should be of uniform size in the population.
- The seed should be healthy and free of any parasite infection, lesion, or deformity.
- The seed should show agility in swimming and good reflexes in response to any object brought closer to it.

Seed transport and stocking

Seed transport and stocking in the grow-out ponds are important considerations for post-stocking survival in culture ponds. The following points are important for consideration.

- Conditioning of the seeds should be done in the hapas before seed packing/transportation.
- Approximately 200 numbers fingerlings should be packed per polythene bag containing 8 liters of water (1/3rd water and 2/3rd oxygen) for a journey of 12 hours.
- Seed transport should be done in the cool hours.
- The transported seed must be acclimatized properly before release in the culture pond
- The density of seed of pacu to be stocked in the culture pond largely depends on the culture method to be adopted, seed size at stocking, and the intended species with which it would be cultured in a multispecies system.
- For a single stock-single harvest cropping pattern, using fingerling as the stocking material, a density of 1.0 fingerling/m2 should be used for monoculture, whereas the density should be suitably doubled in case of a single stock-multiple harvest method under monoculture.
- In the case of the co-culture of pacu with the polyculture of Indian major carp, viz. rohu, catla, and mrigal, the density of pacu should constitute only 15-20 % of the overall stocked population
- Pacu should be cultured at 30-50% of the species composition along with *Pangasianodon hypophthalmus* in bi-species culture.

Management of pond environment

Post-stocking pond fertilization should be done with alternate weekly application of manure (0.5 t cow manure/ha-m) and inorganic fertilizers (10 kg urea and 15 kg SSP per ha- m) for continuous and sustained availability of nutrients for plankton growth. Poultry litter, pig dung, etc., depending on their availability, can also be used as alternative organic manure.

Intermittent liming (@ 200 kg/ha-m of $CaCO_3$) and fertilization measures during culture should be carried out in a grow-out pond. Maintenance of optimum water pH (7.5-8.3) and dissolved oxygen content (>4 mg/l) in the pond are the most critical factors during the grow-out culture.

Monitoring of the important water quality parameters of the grow-out pond should be done at regular intervals. Water parameters should be checked preferably every week to take timely suitable correction measures.

Food and Feeding Management

In semi-intensive/intensive culture systems, natural fish food production only partially meets the food demand while the energy requirement for somatic growth after fulfilling the sustenance demand can only be met through feed supplementation from outside. Supplementary feed constitutes more than 60% of the production cost. Therefore, while good quality feed is important to attain suitable growth in the cultured organism, feeding management saves feeding costs, puts a curb on the waste, and reduces water quality deterioration.

The feeding habit of pacu is almost similar to the Indian major carp. While the mixture of groundnut/mustard oil cake and rice bran has been the most commonly used supplementary feed for carp, commercial feed pellets with balanced formulations have been in use in recent years. Commercial pellets with crude protein of 25-30% and crud fat of 4-6% along with appropriate quantities (1.0%) of vitamins and minerals are now being used for grow-out culture. Since pacu feeds in the surface-to-column niche, the use of extruded floating pellets for the fish gives better control in feed management.

In terms of feed dispensation, the feed mixture, if used, should be provided in the form to dough in trays, hung at different depths in the pond. Feeding preferably twice a day is advocated. Fixing of daily ration of supplementary feed is important since underfeeding depresses growth while overfeeding results in wastage of food and deterioration of water quality. Feeding should be made two times a day and feed should be provided @ a maximum of 5-6 % of the body weight per day initially (up to about 50 to 80 g body weight), and as the stock grows the feeding rate should be reduced to about 2-3% bodyweight per day. The biomass of the fish should be calculated through periodic sampling considering the average body weight and assumed survival for estimation of the daily feed ratio.

Feed procurement and storage and use

- The time between manufacture and use of the feed should not exceed two weeks.
- The feed should be stored to permit good air circulation, at least 20cm above the ground on a wooden platform, protected from direct sunlight, rain, and wind.
- Each feed bag should be smelled before being used for rancidity and rancid feed bags must be discarded.

Aeration and water exchange

Dissolved oxygen (DO) is probably the most important single variable regulating production of fish in intensive culture. In grow-out pond, particularly with high density culture, the DO level should always be maintained above 5-6 mg/l. Aeration should be used mechanically to increase the DO in ponds using several models available in the market. Of the three major types of pond aerators available viz., the paddle wheel, the aspirator, and the submersible aerators, the first one being a surface aerator should be ideal for a water depth of 1.0 to 1.5 m, while the other two are considered to be more effective in deeper ponds due to their high injection capacity.

Water exchange is another important activity, considered to be crucial in the case of intensive aquaculture operations. Due to the continuous accumulation of metabolites and decayed unutilized feed, besides heavy organic manuring, the water environments deteriorate, leading to slow growth of fish species and often leading to outbreak of diseases. Therefore, if possible 10-15% of the water should be replaced, particularly from the bottom area, at regular intervals, especially during the later part of the culture period in case of intensive culture practices.

- Water exchange rate and frequency should be decided based on the water quality evaluation.
- If possible, a water intake and discharge schedule/ calendar should be made and all the nearby farmers should try to follow the same discharge and intake schedule.
- The intake water should be filtered through the use of screens.
- It is advisable to have a reservoir tank/ canal to store water before discharge

Health management

The fishes in grow-out ponds should be periodically sampled for health check-up in terms of their growth and robustness, presence of any parasitic/ bacterial/oomycete diseases, lesions in the body and fin, etc. Maintenance of suitable water quality and optimum feeding regime can prevent most of the disease outbreak. However, the following measures should be undertaken;

- The fish should be observed regularly for abnormal or unusual behavior.
- All clinical signs should be recorded
- All dead fish should be removed and safely disposed of.
- Moribund samples should be used for disease diagnosis
- Without understanding the cause of the disease, the use of drugs/chemicals should be avoided, and the treatments should be made very judiciously based on diagnosis results, only.
- When discharging water from diseased ponds, other farmers in the area should be informed well before.
- No banned chemical should be used at any stage of the farming process.
- Chemicals or other substances claimed to improve water quality by different agencies should only be used after due consultation with qualified personnel and under supervision

Harvesting

The harvest size and duration of culture varies depending on the culture practice in different states. Based on the survey undertaken in one of the research projects funded by the National Fisheries Development Board, Hyderabad, it has been observed that in Andhra Pradesh, most of the farmers harvest at a size of 1.0–1.1 kg, and the culture duration varies between 6 and 7 months. The average culture duration in West Bengal is about 8 months where pacu attains 500-800 g in weight. In Kerala, most of the farmers culture pacu for a period of 12 months, and the size range vary between 1.0–1.3 kg. In polyculture with carp, pacu attains higher body weight than those of Indian species. Therefore, the culture period and harvesting size should be decided, depending on the culture practice and demand.

Post-harvest management

Fish that have been harvested should be placed in a container with ice-cold water that is between 4 and 5 degrees Celsius to kill the fish. Chill killing enhances the quality of preservation and lessens the intense physical strain experienced just before death. The fish should next be graded and arranged in boxes with fish and ice layers alternately. For long-distance shipping, the crates should be packed in an insulated transport truck. It is best to drain the pond's water after the crop has been harvested. The bottom of the pond should be exposed to sunshine until cracks start to appear. Organic deposits in the upper layer of the pond should be scraped off and removed if needed.

Harvested fish should be collected in a container having ice chilled water with 4-5°C temperature for killing the fish. Chill killing reduces the rigorous physical stress prior to death and improves the

keeping quality. Subsequently, the fish should be graded and placed in crates in alternate layers of fish and ice. The crates should be stacked in an insulated transport truck for long-distance transport.

After harvesting of the crop, the water from the pond preferably should be drained out. The pond bottom should be exposed to sunlight till the development of cracks. If necessary, organic deposition in the top layer should be scrapped and removed from the pond. All the required repairs of the dykes, inlet, and outlet structures should be completed during the inter-cropping period to prepare the pond for the next crop.

Avoiding escape of cultured pacu to natural water bodies

As per the Convention on Biological Diversity, it is the moral and legal obligation of our country to conserve native biodiversity. Since adverse impacts of any exotic fish species become effective only after a long time and there is no foolproof system to prevent escapes, it is required to take adequate safeguards to prevent entry/minimizing escape of any of the exotic fishes including pacu into natural water bodies. Therefore, the following precautionary measures should be undertaken;

- ✓ Based on the information available (on government records) regarding flood history over the preceding 50 years, the height of the pond dyke should be greater than the maximum water level and there should be a sufficient land barrier to the natural water bodies.
- ✓ Trapping devices should be placed in drainage canals or water outlets and frequently examined for the escape of pacu fish; if identified, appropriate measures should be taken to prevent escape.
- ✓ The strength and stability of the pond dike must be assured.
- ✓ Hobbyists and ornamental fish keepers shouldn't purchase young fish because there's a chance the fish could be released into the wild after they outgrow their tanks.

Conclusion

Pacu farming in India holds great potential for contributing to the country's aquaculture landscape. With its impressive growth rate, adaptability, and consumer demand, *Piaractus brachypomus* offers farmers a lucrative opportunity to diversify their production. However, to fully harness the benefits of pacu culture, it is crucial to follow best practices and adhere to well-established guidelines that prioritize sustainability, environmental responsibility, and economic viability. By implementing proper farming techniques, optimizing water quality management, and adopting sustainable feeding practices, Indian fish farmers can maximize the production potential of pacu while minimizing the ecological impact.

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BROOM GRASS: A VALUABLE YET OVERLOOKED CROP IN SIKKIM AND DARJEELING HIMALAYAS

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Abstract
Broom grass (*Thysanolaena maxima Roxb.*), a member of the Poaceae family, grows mostly in hilly slopes as tall, crested, perennial grass. It is a used for cleaning floors, lime washing walls, and providing good forage with its leaves and chewable culms. Its woody culms are utilized for fuel and mulch material. Broom grass also holds medicinal value, as its roots' extract is used as a mouthwash during fever and the dried paste of fresh roots is applied on the skin to check boils. Broom grass growers in the sub-Himalayan region of West Bengal and Sikkim are facing several challenges that are affecting their cultivation and livelihoods. To address these challenges, broom grass growers need to adopt integrated approaches. These approaches should include improving access to technology, establishing better market linkages, providing training in modern agricultural practices, and implementing supportive policies that enhance their resilience.

Key words: Broom grass, Sub-Himalayan Region, West Bengal, Sikkim, Improving

Introduction

Broom grass (*Thysanolaena maxima* Roxb.), a member of Poaceae family, is tall, crested, perennial grass which grows mostly in hilly slopes. It is generally known as *tiger grass*, *broom grass* and *bouquet grass* in English; *jhadu ghas* in Hindi; *amliso* in Nepalese; *phool jhadu* in Assamese. It grows well in temperate and subtropical parts of China, India, Bhutan, Myanmar, East Asia, Nepal, Malaysia and New Guinea up to 2000 m elevation (Watson and Dallwitz, 1992). Its flowering period occurs during June - July and bears inflorescence on the shoot apex at the end of vegetative phase. Broom grass is a significant non-timber forest resource and is widely used for cleaning floors, lime washing of walls, its leaves and chewable culms make good forage and its woody culms are used for fuel and as mulch material (Mohiuddin and Alam, 1987). Broom grass also has medicinal values, with a extract of the roots used as a mouthwash during fever and the dried paste of fresh roots is applied on the skin to check boils (Rai and Sharma, 1994). Its soft twigs are good cattle feed for improving milk production, and elephants also feed the whole plant and there are also reports that its fruits have anti fertility properties (Mudgal and Pal, 1980). Its fibroid root mat effectively protects the top soil and nutrients loss from erosion. In landslides affected areas and in agricultural fields the water run-off and soil loss are reduced by up to 88% compared to bare areas (Bhuchar, 2001).

Broom grass cultivation in the Himalayan region of Darjeeling, Kalimpong district of West Bengal, and Sikkim mainly takes place in its natural setting without much human intervention. As a result,

the production and productivity are quite low. The factors like uncertain weather condition, traditional agricultural practices, and seasonal market demand makes the profitability from broom grass is highly uncertain. The broom grass has been silently supporting the livelihood of the hill populace since ancient times but did not receive much attention from policymakers for its systematic cultivation, value addition and marketing. The farming policy with scientific broom cultivation practices supported by an industrial set – up could further support the life and livelihood of hill people.

Multiple Uses of Broom Grass

1. **Brooms:** *T. maxima*, is a perennial, high value, non-perishable and multipurpose cash crop (Bisht and Ahlawat, 1998). It is extensively used for the manufacture of soft brooms using its inflorescences (Namsa *et al.,* 2011). According to (Shankar *et al.,* 2001), an individual can earn 1.7 times more than his investment within six year planting cycle. The strong and bendable stalks of broom grass are ideal for creating long-lasting brooms.
2. **Paper and Pulp:** Fibers obtained from broom grass have an average length of 1.25 mm and a yield of 45% (unbleached). The good grade paper sheets can be produced from *T. maxima* in laboratory with burst factor of 30, breaking length of 3,555 m and tear factor of 106 (Saikia *et al.,* 1992). Therefore, it can be recommend that *T. maxima* could potentially serve as a raw material for production of pulp and paper, either on its own or in amalgation with other raw materials. This material has the capability to meet future demands for raw materials in the pulp and paper industry if properly utilized its pulp can also be used to make insulation boards.
3. **Medicinal Application:** The different part of broom grass has multiple medicinal uses folks of North Sikkim in India reported that a decoction of 200-300 grams of its young roots for one dose is used twice a day to treat gular problem. Poultice of young flowers is used in arthritic pain and skin swelling (Maity *et al.,* 2004). The extract of root is used as a mouthwash during fever (Rai, 2003), and mixing extract with common salt is used as remedy for mouth sore (Pal and Jain, 1998). As an helmintic, two teaspoon of root juice (5 pieces about 10 cm long) are given two times a day for 2-3 days to patient (Shrestha, 1985). Further broom grass has strong anti-microbial property and its roots could positively retaliate against bacterial strains like *Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis and Escherichia coli* (Mahato and Chaudhary, 2005).
4. **Fodder:** The tender culms, leaves and spike of *T. maxima* are used as fodders for bovines during lean period (Malla and Chhetri, 2009). As per the nutritional analyses, *T. maxima* leaves are found to have a balanced proportion of nutrients making them as good fodder and forage for livestocks, which is shown in the following table 1.

Table 1: Nutritional Profile of Broom Grass

Parameter	Content (%)
Digestibility	54.3 – 57.9
Total Ash	10.7 – 11.8
Ether extract	4.2 – 6.7
N-free extract	39.3 – 44.6
Crude protein	15.1 – 18.2

Parameter	Content (%)
Crude fiber	29.5 – 31.0
Cellulose	30.3 – 37.8
Hemicellulose	29.6 – 34.4
Lignin	4.6 – 9.2

Source: Bhuchar, 2008

5. **Fencing and Fire Stick:** After harvesting, broomsticks culms are used as fencing or wall-building substance. They are readily available in areas where broom grass is cultivated, providing a cost-effective fencing solution. The dried culms of broom grass can be used as fire sticks due to their ability to ignite quickly and burn gradually. In some rural areas and villages broom grass culms serve as an accessible source of fuel for cooking fodder.
6. **Erosion Control:** *T. maxima* has also been reported to have good soil and water conservation property. Its cultivation encourage the sustainable use of fragile and degraded lands (Shankar *et al.,* 2001). The plants can be used as shelter belts and wind break which bind the soil and protect top soil and nutrients from erosion on incline terrain. It has a strong, substantial root system that tie up the soil, reducing soil erosion caused by excess water runoff. The dense covering of broom grass helps in reducing the impact of raindrops on the soil, thereby decreasing soil replacement.

Income Potential from Broom Grass Cultivation

Income from broom grass cultivation in different states of India varies remarkably, affected by factors such as local demand, production scale, and market access. In Assam, farmers earn Rs. 30,000-50,000 from broom cultivation with each broom selling for Rs.15-25. The market in Assam fetch both local and national demand. Likewise, in Nagaland, farmers make an annual income of Rs.25,000-45,000 per acre by selling brooms for Rs. 20-30 each. In Tripura, farmers earn between Rs. 35,000-55,000 per acre by selling brooms for Rs. 18-28 each. Meghalaya is known for its good-quality broom grass, and farmers are making an annual income upto Rs. 40,000 – Rs. 60,000/ acre by selling broom @ Rs. 18-28/ each. Darjeeling has a smaller production scale, with brooms priced at Rs. 20-30/ piece, farmer here earns an annual income between Rs. 30,000-50,000 per acre. In Sikkim, brooms are priced at Rs. 18-28 each, and farmers are getting around Rs. 25,000-45,000 per acre from broom grass cultivation. These numbers shows the economic potential of broom grass cultivation across these region. Farmers can enlarge their earnings through adoption of better cultivation practices, better marketing and value addition activities.

Issues with Broom Grass Cultivation

Broom grass growers in the sub-Himalayan region of West Bengal and Sikkim are facing several challenges that are affecting their cultivation and livelihoods. Here are some familiar problems that broom grass growers in these areas are facing:

1. **Lack of Proper Nutrient Management:** Farmers in this region did not pay any attention on manure and fertilizer application to broom grass. Fertilizers and Manures play a critical role in providing essential macro nutrients like (nitrogen, phosphorus, potassium, calcium, sulfur and magnesium) and micro nutrients (boron, chorine, iron, manganese, zinc, copper and molybdenum) that are necessary for plant growth and development. Without adequate

nutrients, broom grass may experience stunted growth and reduced yield. Ceaseless cultivation without replenishing nutrients through organic manure or fertilizers can result in low soil fertility level over time. Farmers refrain from using manure and fertilizer due to cost constraints and perceived lack of economic returns. Lack of awareness about the benefits of nutrient management or proper application techniques may also contribute to farmers' reluctance to utilize manure and fertilizer.

2. **Limited Access to Improved Varieties**: Availability of improved broom grass varieties that are resistant to diseases, pests, and adverse climatic environment is limited in the region. Farmers many times depend on local varieties that may have lower yields or quality.
3. **Market Access and Price Fluctuations**: Access to reliable markets and fair prices for broom grass products can be a challenging task. Farmers may encounter price variation and unfair utilization by middlemen, affecting their earning and profitability.
4. **Lack of Infrastructure**: In some areas, poorly developed infrastructure such as storage facilities, irrigation facilities and transportation networks may result in post-harvest losses and difficulties in reaching markets in a timely manner.
5. **Financial Constraints**: Limited access to credit facilities and institutional support for agricultural inputs and technologies can hinder farmers' ability to invest in their farms and improve productivity.
6. **Labour Shortage**: Availability of skilled labour for activities such as harvesting and processing broom grass is limited, especially during high seasons. This delayed farm operations and increased labour costs.
7. **Government Policies and Support**: Conflicting with government policies related to agriculture, including subsidies, market support, and extension services, affect the profitability and sustainability of broom grass cultivation.

Inscription to these challenges, broom grass growers in the sub-Himalayan region of West Bengal and Sikkim need to adopt integrated approaches that include improving access to technology, establishing better market linkages, providing training in modern agricultural practices, and implementing supportive policies that enhance their resilience.

Solutions for Broom Grass Cultivation

1. **Following Proper Nutrient Management Practices:** The farmer should follow INM practices for better production of broom grass. Application of organic manure like, compost, farmyard manure and green manures will help in improving soil fertility and enhancing yield of broom grass. The farmers should test the soil to find out nutrient deficiencies and apply balanced NPK (Nitrogen, Phosphorus, Potassium) fertilizers appropriately. They should follow intercropping and crop rotation with legumes to improve soil health of broom grass field.
2. **Adoption of Improved Varieties:** High yielding broom grass cultivars like *Munsiari, Darjeeling Green*, *Tikhur,* and *Sikkim local* etc. should be adopted as per the local condition. The villagers should set up community nurseries to produce and supply quality seedlings to local farmers. There is a need to conduct awareness and training programs on the benefits of using improved varieties. The Indian Institute of Soil and Water Conservation (IISWC) under ICAR has developed and selected high-yielding varieties that are well-suited for erosion control and it needs wide – scale popularization through state agriculture department, KVK and NGOs. Several regional research stations of ICAR, mainly in the

Northeastern Hill (NEH) region, have worked on making varieties with enhanced traits such as higher inflorescence yield, disease resistance, and better culm quality.

3. **Market Access and Price Fluctuations:** Farmer should organized themselves in the form of cooperatives FPOs to collectively market broom grass and negotiate for fair prices. They should use different digital platforms for real-time market information and direct sale. Contract farming arrangements should be explored with industries that use broom grass as raw material to ensure stable demand and pricing.
4. **Farm-gate Infrastructure Development:** Proper policy support to develop processing units, storage ware houses, and transportation channels should be provided to realize the income potential from broom cultivation. FPOs can take capital on loans for community-owned processing units to add value and extend the shelf life of broom grass. Farmers need to be motivated for the use of solar drying techniques to reduce post-harvest losses.
5. **Enhance Access to Financial and Credit Services:** Encourage cooperatives and microfinance institutions that provide low-interest loans to provide credit facility to broom growers. Public-private partnerships should be encouraged to create funding opportunities for broom grass cultivation projects.
6. **Promoting Farm Mechanization:** Mechanizing farming operations can address the problem of labour unavailability in broom cultivation. The farmers should be exposed to different labour-saving equipment and tools to reduce dependency on manual labour. The agriculture department can provide training on the use of mechanized equipment. Uses of MGNREGA labour for broom cultivation and post harvest operation can also address the labour issues in the region.
7. **Adopting Sustainable and Environment Friendly Farming Practices:** Implement sustainable farming embrace soil and water conservation techniques such as contour plowing, terracing, and rainwater harvesting. Farmers should adopt agroforestry and integrate broom grass cultivation with other tree species to enhance biodiversity. They should reduce use of chemical fertilizers and pesticides by promoting organic farming methods can lower down the stress on environment and promote sustainable earth.
8. **Government Policies and Support:** Farmers should involve with policy makers to build supportive policies for broom grass including subsidies, cultivation, grants, and schemes. Government should inspire the establishment of farmer assisting services to provide guidance on best practices and government programs.
9. **Capacity Building and Research Development:** The Government should invest in research to develop better varieties for region-specific challenges, and improve cultivation practices. Periodic training and workshops on improved cultivation techniques, pest management, and value addition. Activities should be conducted regularly to update the knowledge and skill of broom grass cultivation.

Conclusion

Broom grass is a valuable yet often overlooked crop in the Darjeeling and Sikkim, contributing countless benefits that extend larger than its traditional use as a broom-making material. Its importance extent environmental, economic, and cultural sphere, making it an integral element of sustainable development in the area. Despite these advantage, broom grass remains as undervalued and underutilized crop in the region. To fully utilize its potential, we need to raise awareness, conduct research, ensuring better marketing facility, establish industrial set – up and built – up

necessary infrastructural facilities to keep – up the optimum benefit from its cultivation. Government support and policies can play a pivotal role in promoting the sustainable use and commercialization of broom grass.

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EXPLORING SOLUTIONS TO EASE WATER STRESS IN PUNJAB AND HARYANA

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Abstract
Water, an essential requirement for humans around globe. Water stress in Punjab and Haryana, which are agriculturally vibrant states in India, has reached alarming levels. Statistical analysis reveals that groundwater levels in Punjab have fallen by approximately 1.5 meters per year since 2000, with 60% of blocks classified as over-exploited. In Haryana, around 80% of irrigated land relies on groundwater, exacerbating the crisis. Implementing suitable measures could potentially upsurge water availability by 20% and lessen the dependency on groundwater. The excessive use of groundwater for irrigation coupled with the region's reliance on water-intensive crops like paddy, has severely depleted the water table. The crisis is exacerbated by climate change, erratic monsoon patterns and the lack of sustainable water management practices. Addressing this issue is not only crucial for the environment but also for the economic stability of these states, which are heavily dependent on agriculture. Hence, this article explores the problems and potential solutions to mitigate the water crisis in Punjab and Haryana, emphasizing sustainable practices, technological interventions, and policy reforms.

Key words*:* Groundwater, Crop diversification, Rain water harvesting

Groundwater Depletion

Groundwater is depleting at an alarming rate. Nearly 79% of blocks in Punjab are overexploited, meaning groundwater is being extracted faster than it can be replenished. Between 2000-2017, groundwater levels in some parts of Punjab dropped by 10-15 meters. Over 90% of irrigation is dependent on groundwater. Groundwater depletion in Haryana is also severe, with over 60% of districts classified as overexploited. Groundwater levels in Haryana have fallen by up to 20 meters in some regions over the past two decades. The State's average decline in the water table from June 1995 to June 2020 is 9.47 metres. Where, out of 7,287 villages, 3,041 villages are groundwater stressed. On the other side, 3,93,092 hectares area or 9% of State's geographical land is affected due to water logging. Agriculture consumes about 90% of the water in Punjab. Rice and wheat, the main crops in the state, are highly water-intensive. Growing 1 kg of rice requires 3,500-5,000 litres of water. About 85% of Haryana's water use goes to agriculture. The cultivation of rice in Haryana uses over 60% of its water resources, despite the state's semi-arid climate.

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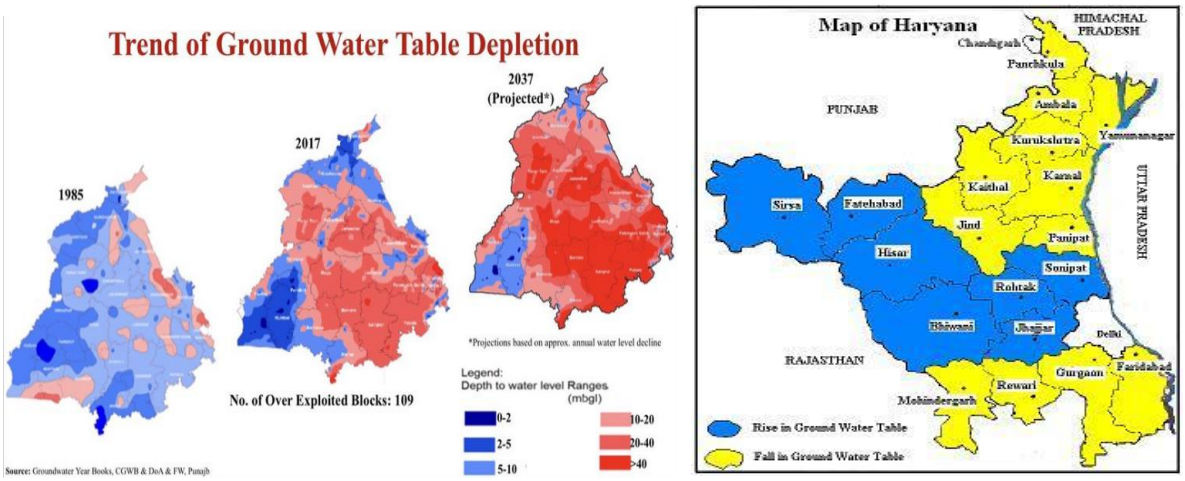

Fig:1 Trend of groundwater depletion in Punjab and Rise and Fall of Water table in Haryana

Table.1: Showing groundwater extraction and recharge in different states of India

Groundwater in select States (2022)

States	Total annual GW recharge (bcm)	Annual GW extractable resource (bcm)	Current annual GW extraction for all uses (bcm)	Stage of GW extraction (%)
Punjab	18.94	17.07	28.02	165.99
Rajasthan	12.13	10.96	16.56	151.07
Haryana	9.48	8.61	12.42	134.14
Delhi	0.41	0.37	0.36	98.16
Tamil Nadu	21.11	19.09	14.43	75.59
UP	71.45	65.30	46.14	70.66
Karnataka	17.74	16.04	11.20	69.93

Source: CGWB 2022 GW: Groundwater

Punjab and Haryana have historically relied on their rich alluvial soil and abundant water resources to become India's breadbasket. However, the Green Revolution, which brought about an agricultural boom in the 1960s and 1970s, also led to the extensive use of water-intensive crops like rice and wheat. The indiscriminate use of groundwater for irrigation has resulted in a severe depletion of the water table, with levels dropping by over a meter annually in some regions. The Central Ground Water Board (CGWB) has classified most of the districts in Punjab and Haryana as "over-exploited" or "critical" in terms of groundwater availability.

Climate change is further exacerbating the water crisis in these states. Erratic rainfall patterns and prolonged droughts have made the monsoon unreliable, further increasing dependence on groundwater. Additionally, rising temperatures lead to higher evapotranspiration rates, requiring even more water for crops. The increasing unpredictability of the monsoon season has also disrupted traditional farming cycles, making water management even more challenging. The over-extraction of groundwater and reduced rainfall recharge, aquifers are depleting rapidly, leading to a severe water crisis. The primary existing scheme aimed at addressing groundwater depletion in Punjab and Haryana is the "Atal Bhujal Yojana" (also known as "Atal Jal"), a central government

initiative focused on community participation and demand-side interventions for sustainable groundwater management in water-stressed areas like these states; it encourages practices like crop diversification away from water-intensive crops like paddy and promotes efficient irrigation methods like drip irrigation.

Potential Solutions to mitigate water crisis

Crop Diversification

One of the most effective solutions to the water crisis is crop diversification. Punjab and Haryana need to move away from water-intensive crops like paddy and wheat and encourage the cultivation of less water-demanding crops such as pulses, millets, and oilseeds. Punjab and Haryana fall under medium crop diversification and high crop diversification states. These crops not only require less water but also improve soil health, reducing the need for chemical fertilizers. Under the *"merapani-merivirasat"* program, the Haryana government has also encouraged diversification by offering a per-acre incentive of Rs. 7000 for switching to a different crop.

Adoption of Efficient Irrigation Techniques

Traditional flood irrigation methods are highly inefficient, with significant water losses due to evaporation and seepage. The adoption of micro-irrigation techniques, such as drip and sprinkler systems, can drastically reduce water usage. These systems deliver water directly to the root zone of the plants, minimizing waste and ensuring optimal water use. Government schemes like the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) should be effectively implemented to promote micro-irrigation in the region.

Water Harvesting and Recharge Initiatives

Rainwater harvesting and groundwater recharge are critical for replenishing the depleting water table. Both states should invest in the construction of check dams, percolation tanks, and recharge wells to capture and store rainwater. Additionally, traditional water bodies like ponds and lakes should be restored and maintained to enhance groundwater recharge. Public awareness campaigns can also be conducted to encourage communities to adopt rainwater harvesting at the household level.

Fig.2: Strategies to combat water stress in states of Punjab and Haryana

Policy Reforms and Governance

Strong policy measures are needed to regulate groundwater extraction and promote sustainable water use. The implementation of a comprehensive water policy that includes groundwater management, water pricing and allocation of water resources is essential. The government must

enforce laws that prevent the over-extraction of groundwater and promote the judicious use of surface water. Additionally, the formation of water user associations (WUAs) can empower farmers to manage water resources collectively and ensure equitable distribution.

Technological Interventions

The use of technology can play a significant role in addressing the water crisis. Satellite-based monitoring systems can track groundwater levels and provide real-time data to policymakers and farmers. This data can be used to regulate water use and prevent over-extraction. Additionally, the adoption of precision farming techniques, such as soil moisture sensors and automated irrigation systems, can optimize water usage and reduce wastage.

The Government of India has several schemes for groundwater management, including:

1. **Atal Bhujal Yojana (Atal Jal):**
   This scheme aims to improve groundwater management in water-stressed areas through community-led efforts. The scheme is being implemented in Haryana and other states, including Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh.
2. **Groundwater augmentation through artificial recharge:**
   The Central Ground Water Board (CGWB) has taken up this project to reduce water-stress in areas of Rajasthan and Haryana.
3. **National Aquifer Mapping and Management Programme (NAQUIM):**
   This program aims to develop plans for groundwater management by characterizing and delineating aquifers.
4. **Jal Shakti Abhiyan (JSA):**
   This scheme is being implemented by the Government of India. It aims to address water scarcity in India through a range of objectives like water conservation, community participation and campaigns like Jal Shakti Kendra's at district headquarters.
5. **Amrit Sarovar Mission:**
   This mission was launched by the Prime Minister on April 24, 2022 to conserve water and develop water bodies in India through people's participation, soil utilization and livelihood generation.
6. **Ground Water Management and Regulation (GWM&R) scheme:**
   This scheme is being implemented by the Central Ground Water Board. The ultimate goal of groundwater management is to ensure that there is enough safe water for people to use for health, productivity and livelihood.

Case Study:

The State Action Plan on Climate Change of Punjab too attributes intensification of rice cultivation as the foremost challenge facing its agriculture sector. It warns of a grim future in terms of acute water shortage, depleted quality of soil and livelihood crises owing to rising climate impacts in future.

The situation necessitates urgency for adoption of sustainable agricultural practices to reduce depletion of groundwater, promote better residue management practices, increase efficiency and promote adaptation to climate change. DSR is one such practice that promotes sustainable agricultural practices. Baldev Singh is a farmer who owns 31 acres of land and grows wheat and paddy at Talwandi Bhangerian village in Punjab's Moga district. He switched from traditional rice

cultivation i.e., transplanting sprouted seedlings from a nursery into standing water in the past years to a more sustainable direct seeding which includes sowing and sprouting on the field. This reduced labour costs and cut down consumption of water and electricity. According to Singh, use of DSR machine on his field saved Rs 5,000 per acre on labour, diesel and fertilisers and halves water and electricity usage. He also noticed an increased yield of two quintal per acre in successive wheat crop. He attributed this to added nutrition through paddy residue in soil and uniform sowing through Happy Seeder — for sowing wheat without having to burn the paddy residue. Singh's success story is part of the bigger response intervention under Indo-German bilateral cooperation which focusses on systemic change in agricultural practices in Punjab aimed at overall climate adaptation responses. Through an active network of farmers and experts, farmers are encouraged to adopt structured process involving DSR sowing machines such as Seed Drill and Lucky Seed Drill for paddy cultivation; harvesting of paddy and use of cutter, bailers and ploughs for further cutting, crushing and mixing of paddy; and the use of Happy Seeders for successive crop cultivation.

Challenges and recommendations

The shift to DSR is more challenging. Yet farmers have been reluctant to shift from traditional practices due to:

- The availability of free electricity and water for agriculture
- Procurement of rice through minimum support price
- Lack of awareness and knowhow of practicing DSR
- Established rice cultivation practices for generations

Some farmers have been unwilling to use specific early maturing rice varieties for DSR such as PR 126 and PR 127, due to yield issues. There are challenges related to weed management as well as a normal seed drill machine for DSR requires immediate manual spraying of weedicides. A delay can lead to significant growth of weeds. This challenge is removed by the newly designed Lucky Seed Drill, which simultaneously sows and sprays weedicides in fields. German Agency for International Cooperation (GIZ) work demonstrated the use of Lucky Seeder in 2019 and 1,000 acres were successfully covered under DSR through the use of 5 Lucky Seeder machines. Even so, Lucky Seed Drill and Happy Seeder are expensive machines, costing up to Rs 1 lakh even after provision of subsidy. Experts in Punjab Agricultural University (PAU), a partner in GIZ's effort, pointed out that all farmers need not own a machine. Custom hiring can be the way forward.

Summary

The water crisis in Punjab and Haryana is a complex issue that requires a multi-faceted approach. Sustainable agricultural practices, efficient irrigation techniques, rainwater harvesting, and strong policy measures are essential to address the crisis. While the challenges are significant, the solutions are within reach. With the right combination of government intervention, technological innovation, and community participation, Punjab and Haryana can overcome their water woes and ensure a sustainable future for agriculture in the region. It is imperative that these solutions are implemented with urgency, as the water crisis threatens not only the livelihoods of millions of farmers but also the food security of the nation.

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PROBIOTICS AND THEIR ROLE IN RUMEN FERMENTATION AND ANIMAL PERFORMANCE

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Abstract
Probiotics, which are live beneficial bacteria, are essential for enhancing rumen fermentation and ruminant performance as a whole. Probiotics assist stabilize rumen pH, improve fiber digestion, lower methane emissions, and increase microbial protein synthesis via modifying the rumen's microbial environment. Better nutrient utilization, faster development rates, higher milk production, and stronger immune systems are the results of these impacts. Probiotics provide a safe, natural way for livestock farmers to increase the productivity of their ruminant production systems while preserving animal health and environmental sustainability.

Keywords: Probiotics; Rumen Fermentation; Animal Performance; Nutrient Utilization; Microbial Health

Introduction

Probiotics are live bacteria that give the host health benefits when given in sufficient doses. They have attracted a lot of interest lately for their potential to improve animal health, increase digestive efficiency, and improve overall performance in livestock production. Probiotics are especially important in ruminants because they regulate rumen fermentation, a process that is necessary for the digestion of fibrous plant matter. This article describes how probiotics affect microbial populations, nutrient consumption, and the general health and productivity of ruminants. It also discusses the role of probiotics in rumen fermentation and how they affect animal performance.

Understanding Rumen Fermentation

Within the digestive system of ruminants is a complex, anaerobic fermentation chamber called the rumen. Here, a varied microbial community comprising bacteria, protozoa, fungus, and archaea breaks down fibrous plant material into volatile fatty acids (VFAs), gasses, and microbial protein. For ruminants, these VFAs - mainly acetate, propionate, and butyrate serve as their primary energy sources. In addition, microbial protein, which is produced in the rumen and absorbed in the small intestine, is an essential supply of amino acids. The fermentation of rumen is a highly controlled and precise process. Digestion, nutrition absorption, and general animal performance can all suffer from any disturbance to the microbial equilibrium. Stress, feeding practices, and the makeup of the diet can all have an impact on the microbial communities in the rumen, which can occasionally result in disorders like acidosis that have a negative effect on the productivity and health of the animals.

Probiotics: A Tool for Modulating Rumen Microbial Populations

Probiotics are used in ruminant nutrition to positively influence rumen microbial populations. They can include strains of bacteria such as *Lactobacillus*, *Bifidobacterium*, and *Enterococcus*, as well as yeast species like *Saccharomyces cerevisiae*. These microorganisms are selected for their ability to survive in the rumen environment and contribute to the stabilization of rumen fermentation.

Bacterial Probiotics: Certain bacterial probiotics can outcompete harmful bacteria, thereby reducing the risk of ruminal disorders. For example, *Lactobacillus* species are known for their lactic acid-producing capabilities. By converting lactic acid to propionate, they help prevent the accumulation of lactic acid, reducing the risk of acidosis, a condition characterized by low rumen pH.

Yeast Probiotics: Yeast probiotics, particularly *Saccharomyces cerevisiae*, are widely used in ruminant diets due to their ability to enhance fiber digestion. Yeasts stimulate the growth of cellulolytic bacteria, which are responsible for breaking down cellulose into VFAs. Additionally, yeast can scavenge oxygen within the rumen, creating an anaerobic environment that is conducive to the growth of beneficial anaerobic microbes. This helps stabilize rumen pH and improve feed efficiency.

Effects of Probiotics on Rumen Fermentation

Probiotics exert several beneficial effects on rumen fermentation, which in turn influence animal performance:

Stabilization of Rumen pH: One of the primary benefits of probiotics is their role in maintaining rumen pH within an optimal range (6.2-6.8). This is crucial because fluctuations in pH can disrupt microbial populations and impair digestion. By promoting the growth of lactic acid-utilizing bacteria and enhancing fiber digestion, probiotics help prevent sharp drops in pH that can lead to subacute or acute ruminal acidosis.

Enhancement of Fiber Digestion: Probiotics, particularly yeast-based ones, enhance the breakdown of fibrous plant material by promoting the activity of cellulolytic bacteria like *Fibrobacter succinogenes* and *Ruminococcus flavefaciens*. This leads to increased production of VFAs, particularly acetate and butyrate, which are essential energy sources for the animal. Improved fiber digestion translates to better feed efficiency, allowing ruminants to extract more energy from their diets.

Reduction of Methane Production: Methane is a byproduct of rumen fermentation and represents an energy loss to the animal. Certain probiotics can reduce methane production by altering the population of methanogenic archaea or by shifting fermentation pathways towards propionate production, which is less associated with methane generation. Reduced methane emissions not only improve feed efficiency but also have positive environmental implications.

Enhanced Protein Synthesis: Probiotics can enhance microbial protein synthesis in the rumen, which is an important source of amino acids for the animal. This is particularly beneficial for ruminants fed diets low in bypass protein. By increasing the flow of microbial protein to the small intestine, probiotics help improve nitrogen utilization and support better growth rates and milk production.

Impact of Probiotics on Animal Performance

The benefits of probiotics in rumen fermentation translate into improved overall animal performance. This includes enhancements in growth rates, milk production, feed conversion efficiency, and immune function.

Improved Growth Rates and Feed Efficiency: In growing ruminants, such as beef cattle and lambs, the use of probiotics has been shown to improve average daily gain (ADG) and feed conversion ratio (FCR). By enhancing nutrient digestion and absorption, probiotics allow animals to grow more efficiently, reducing the time to market weight and lowering feed costs.

Increased Milk Production: In dairy cows, probiotics have been associated with increased milk yield and improved milk composition. By stabilizing rumen pH and enhancing fiber digestion, probiotics support the production of acetate, a key precursor for milk fat synthesis. Studies have shown that cows supplemented with probiotics like *Saccharomyces cerevisiae* produce more milk with higher fat content, which is desirable in dairy production.

Enhanced Immune Function: Probiotics also play a role in modulating the immune system, which is crucial for maintaining animal health and performance. They can stimulate the production of immunoglobulins and enhance gut health by outcompeting pathogenic bacteria. This can lead to reduced incidences of diseases such as mastitis in dairy cows and improved overall resilience to stressors.

Practical Considerations for Probiotic Use in Ruminants

While the benefits of probiotics are well-documented, their efficacy can vary depending on several factors, including the type of probiotic, the dosage, the animal's diet, and environmental conditions. Therefore, it's important for livestock producers to consider these factors when incorporating probiotics into their feeding programs.

Selection of Probiotic Strain: Not all probiotics are equally effective for all ruminants. The choice of probiotic should be based on the specific needs of the herd, such as the prevalence of ruminal disorders, the type of diet, and the production stage of the animals. For example, yeast-based probiotics might be more beneficial for dairy cows during early lactation when they are at a higher risk of acidosis.

Dosage and Administration: The effectiveness of probiotics depends on administering the correct dosage. Under-dosing may not provide the desired benefits, while over-dosing could be economically wasteful. Probiotics can be delivered through feed, water, or as a direct-fed microbial, depending on the production system and management practices.

Dietary Interactions: The diet of the animal can influence the effectiveness of probiotics. For instance, high-concentrate diets may benefit more from probiotics that help stabilize rumen pH, while high-forage diets may see more benefit from probiotics that enhance fiber digestion. It's important to consider the overall diet composition when selecting and using probiotics.

Environmental Conditions: Factors such as temperature, humidity, and stress levels can affect the efficacy of probiotics. Animals under stress, such as during weaning or transportation, may benefit more from probiotic supplementation due to their potential immune-boosting effects.

Conclusion

Probiotics are now recognized as important instruments in the diet of ruminants, providing a safe and efficient way to boost rumen fermentation and raise animal productivity. Probiotics aid in pH stabilization, improve fiber digestion, lower methane emissions, and increase microbial protein synthesis via modifying the rumen's microbial ecology. These impacts result in observable advantages like higher growth rates, more effective feeding, higher milk production, and

strengthened immune systems. The future of ruminant production will depend heavily on the strategic use of probiotics in feeding regimens, as livestock producers strive to maximize productivity while preserving animal health and environmental sustainability.

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PUSA PURPLE CAULIFLOWER-1: NEW REVENUE STREAMS FOR UTTAR PRADESH FARMERS WITH A NUTRITIONAL POWERHOUSE

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Abstract

PUSA Purple Cauliflower-1 is a groundbreaking variety developed by the Indian Agricultural Research Institute (IARI), combining vibrant aesthetics with enhanced nutritional value. This article explores the origins, genetic traits, and cultivation practices of this unique cauliflower, emphasizing its rich anthocyanin content and health benefits. Special attention is given to its potential in Uttar Pradesh, where the variety's adaptability and premium market positioning offer farmers an opportunity to diversify crops and increase income. As consumer demand for nutritious, visually appealing produce grows, PUSA Purple Cauliflower-1 emerges as a promising crop for sustainable agriculture and economic growth.

Introduction

PUSA Purple Cauliflower-1 is a groundbreaking variety developed by the Indian Agricultural Research Institute (IARI), combining vibrant aesthetics with enhanced nutritional value. This article explores the origins, genetic traits, and cultivation practices of this unique cauliflower, emphasizing its rich anthocyanin content and health benefits. Special attention is given to its potential in Uttar Pradesh, where the variety's adaptability and premium market positioning offer farmers an opportunity to diversify crops and increase income. As consumer demand for nutritious, visually appealing produce grows, PUSA Purple Cauliflower-1 emerges as a promising crop for sustainable agriculture and economic growth. It is one of the most important vegetable crops grown in the tropical and subtropical parts of the world. Purple cauliflower may seem like just a colorful variation of the traditional white cauliflower. Anthocyanins play the most important and crucial role in purple cauliflower, which turns white cauliflower into purple. The anthocyanins may help in reducing the risk of chronic diseases such as heart disease, diabetes, and certain cancers. Purple cauliflower offers practical benefits for farmers, including

market differentiation, value-added opportunities, crop rotation benefits, crop resilience, seed saving initiatives, increased consumer interest and educational opportunities. By incorporating the purple cauliflower into their farming operations, farmers can diversify their produce offerings, improve profitability and contribute to a more resilient and sustainable agricultural system. Cauliflower is a staple vegetable in many parts of the world, renowned for its versatility, nutritional benefits, and adaptability to various culinary uses. Traditionally, white cauliflower has dominated the market, but recent innovations in agricultural research have led to the development of colorful variants, including the striking PUSA Purple Cauliflower-1 This variety developed by the Indian Agricultural Research Institute (IARI), represents a significant advancement in the field of horticulture, combining aesthetic appeal with enhanced nutritional value. In this article, we explore the origins, genetic traits, cultivation practices, market potential, and the promising opportunities it presents for farmers in Uttar Pradesh (UP).

Origin and Development

PUSA Purple Cauliflower-1 is the result of dedicated research and breeding efforts by scientists at the Indian Agricultural Research Institute (IARI), one of the premier agricultural research institutions in India. Recognizing the growing consumer demand for nutritious and visually appealing vegetables, IARI developed this variety through selective breeding techniques. The aim was to create a cauliflower variety that not only captured the attention of consumers with its vibrant color but also offered superior nutritional benefits, particularly through the enrichment of anthocyanins.

The development of PUSA Purple Cauliflower-1 was driven by the institute's commitment to enhancing the diversity of crops available to Indian farmers, while also addressing the challenges posed by climate change and market demand. The variety was bred to be suitable for the agro-climatic conditions of northern India, ensuring that it could thrive in the region's unique environment while providing farmers with a high-value crop option.

Genetics Behind the Color

The distinctive purple color of PUSA Purple Cauliflower-1 is due to the accumulation of anthocyanins, a type of flavonoid with potent antioxidant properties. These pigments are not just responsible for the vibrant hue but also contribute significantly to the nutritional profile of the vegetable. The genetic basis of this variety involves the expression of specific genes that regulate anthocyanin biosynthesis, a process carefully selected and enhanced through breeding practices at IARI.

Compared to traditional white cauliflower, PUSA Purple Cauliflower-1 exhibits a more complex genetic makeup, where the activation of anthocyanin-related genes leads to the intense purple coloration. This genetic trait does not merely serve an aesthetic purpose but also enhances the vegetable's health benefits, making it a valuable addition to the diets of health-conscious consumers.

Nutritional Benefits

PUSA Purple Cauliflower-1 is a nutritional powerhouse, offering a range of health benefits that set it apart from conventional cauliflower varieties. The presence of anthocyanins in this variety provides powerful antioxidant properties, which are crucial for combating oxidative stress in the body. Antioxidants play a vital role in reducing the risk of chronic diseases, including heart disease, cancer, and neurodegenerative disorders.

In addition to its antioxidant content, PUSA Purple Cauliflower-1 is rich in vitamins C and K, dietary fiber, and folate, making it an excellent choice for maintaining overall health. The high fiber content supports digestive health, while vitamins C and K contribute to immune function and bone health, respectively. The combination of these nutrients with the anthocyanin content makes PUSA Purple Cauliflower-1 a unique and valuable component of a balanced diet.

purple cauliflower benefits health in a unique way due to presence of an antioxidant called anthocyanin. Anthocyanin gives this type of cauliflower its rich purple hue, and it can help prevent heart disease and reduce inflammation. The average anthocyanin concentration in the edible portion is 43.7mg/ 100 g of the edible portion. Average marketable curd weight is 0.76 kg.

Cultivation and Growing Conditions

PUSA Purple Cauliflowe-1 has been specifically bred to thrive in the agro-climatic conditions of northern India, particularly during the winter season when cauliflower is traditionally grown. This variety is well-suited to the cooler temperatures required for optimal cauliflower growth, and it exhibits good resistance to common pests and diseases, making it a robust option for farmers.

The cultivation of PUSA Purple Cauliflower-1 follows similar practices to those used for traditional cauliflower varieties, with some specific considerations to maximize yield and quality. Farmers need to ensure that the plants receive adequate sunlight, as this is essential for the development of the anthocyanins that give the cauliflower its purple color. Additionally, proper irrigation and nutrient management are crucial to maintaining the health of the plants and ensuring a bountiful harvest.

Potential in Uttar Pradesh (UP)

Uttar Pradesh, one of India's largest and most agriculturally productive states, presents a promising opportunity for the cultivation of PUSA Purple Cauliflower-1. The state's diverse agro-climatic conditions, particularly in the western and central regions, are well-suited for cauliflower cultivation. With the increasing awareness of the health benefits of anthocyanin-rich vegetables, PUSA Purple Cauliflower 1 can significantly enhance the crop portfolio of farmers in UP.

Enhancing Farmer Income

One of the most compelling advantages of cultivating PUSA Purple Cauliflower-1 in UP is its potential to increase farmers' income. As a high-value crop with a unique appearance and superior nutritional benefits, PUSA Purple Cauliflower-1 can be marketed at a premium price compared to traditional white cauliflower. This premium pricing reflects the added value of the crop and can lead to higher profit margins for farmers.

The growing demand for colorful and nutritious vegetables in both domestic and international markets offers farmers in UP a lucrative opportunity. By adopting PUSA Purple Cauliflower-1, farmers can tap into niche markets that are willing to pay more for specialty produce. This not only diversifies their income sources but also reduces the financial risks associated with relying on a single crop.

Additionally, PUSA Purple Cauliflower-1 is adaptability to various soil types and resistance to common pests and diseases make it a cost-effective option for farmers. Lower input costs, combined with higher market prices, can significantly boost the overall profitability of cauliflower farming in the region.

Market and Consumer Demand

The introduction of PUSA Purple Cauliflower-1 to the market has been met with enthusiasm, particularly among consumers who are increasingly seeking out nutritious and visually appealing

vegetables. The vibrant color of this cauliflower makes it a standout in grocery stores and markets, attracting attention and encouraging consumers to try something new. Its unique appearance also lends itself well to creative culinary uses, making it popular among chefs and food enthusiasts.

Purple cauliflowers are one of the most vibrant and striking large vegetables growing in the garden. In terms of pricing, PUSA Purple Cauliflower-1 is often positioned as a premium product, reflecting both its unique attributes and the care required in its cultivation. This premium positioning has helped to create a niche market for the variety, where consumers are willing to pay a higher price for the added nutritional benefits and aesthetic appeal. For farmers, this presents an opportunity to diversify their crop offerings and tap into the growing market for specialty vegetables.

Culinary Uses and Popularity

The culinary versatility of PUSA Purple Cauliflower-1 is one of its most attractive features. Its vibrant color and mild, slightly nutty flavor make it a versatile ingredient in a variety of dishes, from simple steamed sides to elaborate gourmet presentations. The color of PUSA Purple Cauliflower 1 tends to hold up well during cooking, making it an excellent choice for dishes where visual appeal is important.

In addition to traditional preparations such as roasting or steaming, PUSA Purple Cauliflower-1 can be used in a variety of innovative ways. For example, it can be pureed into soups for a colorful twist on classic cauliflower soup or used as a base for vibrant cauliflower rice. Its unique color also makes it an eye-catching addition to salads, stir-fries, and vegetable platters, adding both nutrition and aesthetic appeal to meals.

The popularity of PUSA Purple Cauliflower-1 has been further bolstered by the growing trend toward plant-based diets, where it serves as a nutritious and visually appealing ingredient. Its unique color makes it a favorite among food bloggers and social media influencers, who often feature it in visually stunning dishes that appeal to health-conscious consumers.

Environmental and Economic Impact

The cultivation of PUSA Purple Cauliflower-1 has important environmental and economic implications, particularly in the context of sustainable agriculture. The variety's adaptability to different growing conditions and resistance to pests and diseases make it a more sustainable option compared to traditional cauliflower varieties. By reducing the need for chemical inputs such as pesticides and fertilizers, PUSA Purple Cauliflower-1 contributes to more environmentally friendly farming practices.

Economically, PUSA Purple Cauliflower-1 offers farmers an opportunity to diversify their crop offerings and tap into the growing market for specialty vegetables. The premium pricing of this variety can provide farmers with higher returns, helping to support their livelihoods and contribute to the overall economic sustainability of their farming operations.

Future Prospects

Looking ahead, PUSA Purple Cauliflower-1 has the potential to play a significant role in the future of agriculture and food consumption. As consumer demand for nutritious and visually appealing vegetables continues to grow, varieties like PUSA Purple Cauliflower-1 are likely to become more prevalent in markets around the world. Advances in agricultural research and breeding techniques may lead to the development of even more robust and nutritionally enriched cauliflower varieties, further enhancing their appeal.

In addition, the growing awareness of the environmental benefits of sustainable farming practices is likely to drive further interest in varieties like PUSA Purple Cauliflower 1, which offer both economic and environmental advantages. As more farmers adopt these varieties, the availability of PUSA Purple Cauliflower-1 is expected to increase, making it more accessible to a wider range of consumers.

Conclusion

PUSA Purple Cauliflower-1 represents a significant achievement in agricultural innovation, combining aesthetic appeal with enhanced nutritional benefits and sustainable farming practices. As a variety developed specifically for the Indian market, it offers a valuable option for both farmers and consumers, meeting the growing demand for nutritious and visually appealing vegetables. With its unique color, robust genetic traits, and versatility in the kitchen, PUSA Purple Cauliflower-1 is poised to become a staple in the diets of health-conscious consumers and a valuable crop for forward-thinking farmers in Uttar Pradesh and beyond.

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PATCHOULI: AN IMPORTANT PLANT FOR AROMATIC INDUSTRIES IN INDIA

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Patchouli scientifically Known as *Pogostemon cablin* is a perennial aromatic herb having height about 0.5-1.5 meter belongs to the family *Lamiaceae*. This plant is native to Philippines, is extensively grown in Indonesia, Singapore, China, Brazil, Malaysia, West Indies and India. In Asian country aromatic plants grown widely for its natural fragrance and essential oil due to compatible climatic condition therefore it is also known as home of spices and land of perfumes. The patchouli plant was first described by Pelletier Sautelet in Phillipines during 1845 and given named *Pogostemon patchouli*. In India, it was introduced for commercial cultivation by Tata Oil mills in 1942, and its systematic cultivation started in 1962 by Central Institute of Medicinal and Aromatic Plants (CIMAP), subsequently it has been circulated in the different parts of India. In India, it is successfully cultivated in South India, West Bengal, Madhya Pradesh, Assam, Gujarat, Maharashtra and some North Eastern states of India. Patchouli can be successfully cultivated in tropical to subtropical conditions however, it prefers warm and humid climate with the most favourable elevation of 900- 1000 mean sea level having annual rainfall ranging from 1500-3000 mm. For the cultivation of Patchouli the well drained, nutrients rich, loamy fertile soil with adequate rich in humus and organic matter is considered good. Soil pH value ranging from 5.5-8.0 with temperature 20-35°C is preferred for the cultivation of Patchouli (Figure-1 & 2).

The essential oil of Patchouli is used for a variety of purposes such as cosmetic industry, perfumery industry, toiletries, breath fresheners, beverages (Alcoholic & Non- alcoholic), pharmaceutical industries and tobacco industries. It is also used in making different category of creams to help in skin, dandruff, healing wounds and eczema. Patchouli oil also valued for the treatment of antiseptic, stimulant, diuretic, analgesics and irritation. In the Indian medical system the traditional healers are using essence of aromatic plants for the mental peace known as aroma therapy. In aroma therapy patchouli oil has been used for the relief of anti- inflammatory, cytophylactic, insecticide, fungicidal disorder. The common compound found in the patchouli is Patchouli alcohol which is highly useful to cure the neurological disorder such as tension, insomnia and anxiety hence this oil has also comes under the category of medicinal plant. Due to high demand of Patchouli oil equally in national and international market it has received significant importance. In India only, the requirement of Patchouli oil is approximately 300 tonnes per annum while the annual production of oil in India is less than 40 tonnes and remaining requirement is met by importing the Patchouli oil. The multipurpose nature of Patchouli oil increasing its demand at a faster rate compared to other aromatic essential oil.

Patchouli is cultivated in Indian climatic condition through vegetative cuttings because in Indian geographical conditions it is very difficult to grow from seeds therefore; the stem cutting is the only method to propagate this crop, moreover, stem cutting also maintains the genetic superiority. Stem cutting can be prepared from 4 to 5 month from healthy vigorous mother plant growing either in open area or under light shade plant of Patchouli. The pencil like thick and 10-12 cm long terminal stem cutting is considered to be of standard size (Figure-3). A cutting should have 3 to 4 nodes and must be taken during rainy season in the months of June to September and kept to grow in the nursery. In order to fastening the growth of the roots, cutting should be treated through IBA (Indole Butyric Acid), a growth hormone (Figure-4). The cuttings are placed either in nursery bed in the nursery or in poly bags, however the planting stock of Patchouli get ready after 35-40 days for the transplanting (Figure-5).

While planting the Patchouli in the field, the preparation of field is to be done either in the month of July or in August. Transplanting of cuttings can be done throughout the year except for peak summer, winter months and during heavy rains. The first deep ploughing is essential because once the crop will establish, it will survive for 2-3 years depending upon the crop productivity and plant populations therefore; it is essential to have a first deep ploughing. In order to maintain the soil fertility status suitable namaticides, *viz*., carbofuran @ 1.0 kg per hectare is incorporated along with 5-10 tonnes of FYM and 0.5 tonnes of neem cake per hectare must be applied before 10-15 days transplanting of the patchouli seedling in to the field. The major varieties for Patchouli cultivated in India are Singapore strain, Johore, Malaysian, Java and Indonesian. However, the Singapore, Indonesian and Johore varieties are considered to be more suitable in Indian climatic condition. Patchouli plant can be grown as intercrop in combination with plantation crops (Tea, coffee), field crops (sorghum, maize) horticulture crops (coconut, banana) and Medicinal and Aromatic plants to increase the overall productivity of the field. Patchouli is a partially shade loving crop it can be grown as a understory crop with suitable commercially important trees (Teak, poplar, subabul) under agroforestry system which provide the profitable additional income of wood as well as good quality of Patchouli crop.

Usually the leaves of Patchouli become ready for harvesting after 5 to 6 months and this is the time of first harvest of leaves, generally prior to onset of monsoon. Harvesting of leaves should be done during cool hours of early morning or evening. The leaves should be harvested in its adequate and mature stage means neither they should turned to over mature nor to be under mature. For such identification of leaves, the mature leaves should be turned pale green to slightly brown and emits the patchouli odour while passes from cropping area. The stage at which the leaves emit the deep patchouli odour like smell is considered to be suitable for harvesting because at this stage the amount of patchouli alcohol in the leaves is higher. The freshly harvested leaves of Patchouli are placed in the shade for 4 to 7 days depending upon weather condition and then shade dried leaves are transported to the distillation unit for oil extraction purpose (Figure-6). Proper shade drying of patchouli leaves also lead to obtaining maximum and good quality of oil. The time required for harvesting of leaves in the field to the distillation unit should not exceed more than one week because high risk of oil evaporation from the dried leaves.

There is need of safeguard during distillation because the quality and quantity of oil mainly depend upon the distillation process. The quantity and quality of Patchouli oil is depend upon method of distillation; quality of leaves, season of leaves harvested, method of transportation, variety,

geographical location and management of field. The main produce of Patchouli is scented oil which has high demand in market, in addition to oil there are certain other minor produces/ residue of Patchouli that can be sold after their value addition and the extra income can be earned. The low concentration of oil is used in flavour for beverages such as candy, baked goods, gelatine and meat products. The Patchouli oil blends well with other essential oil like sandal wood, clove oil and used in tobacco products and breathe sweetener. The leaves remaining after distillation of Patchouli are shade dried and used for making scented goods, incense stick (Agarbatti etc.), wardrobes and protecting clothes especially woollens from insect damage. The organic waste left in the bottom of distillation unit after extraction of oil is used for making superior quality nutrient rich of vermicompost. The average 40 to 60 quintal of shade dried Patchouli leaves can be produced in 2 to 3 harvest in a year from one hectare, which @ 2.0% recovery of oil can be yield 80 to 120 kg/ hectare of essential oil. The estimation based @ Rs. 1200/ kg can earned gross income of Rs. 96,000/- to 1, 44,000/- per hectare which after deduction of all expenses the net income of Rs. 75,000/- to 90,000/- can be earned/ hectare/ year.

Photographs of Patchouli plants

Figure- 1: A view of single Patchouli plant

Figure- 2: A view of Patchouli plants

Figure- 3: stem cuttings of Patchouli

Figure- 4: Treatment of cuttings by IBA

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Figure- 5: Cuttings of Patchouli in Nursery stage

Figure- 6: Distillation unit used for Patchouli oil extraction

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SEAWEEDS UTILIZATION: AN IMPERATIVE PATHWAY OF EVOLUTIONARY AQUACULTURE

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Highlights

- Seaweed is a renewable resource with significant roles in agriculture, food, and medicine, comprising a substantial portion of global aquaculture production.
- Seaweed farming is labor-intensive, generating employment and income, especially in coastal regions.
- Seaweed improves water quality, is nutritionally rich, and serves as a versatile ingredient in food, cosmetics, and pharmaceuticals.
- Seaweed is increasingly used in aquaculture as a feed supplement and natural fertilizer, enhancing sustainability.
- Despite infrastructure challenges, seaweed farming holds promise for addressing global environmental and food security issues.

Introduction

Seaweed, a marine macroalgae, is a sustainable and renewable resource with a wide range of potential applications in agriculture, food, and medicine (Okolie et al., 2018). Seaweeds are considered a low-priced commodity that contributes around 30% of global aquaculture production (Cai et al., 2021). The annual production of aquatic algae has increased over 60-fold, going from 0.56 million tonnes in 1950 to 35.82 million tonnes in 2019. Out of this total, 97% was derived from cultivation, while 99.84% was sourced from seaweed (FAO, 2021b). Seaweeds are in 5th position in species-wise production of first-sale value was converted into salaries or other forms of income, which helps with 5.4 % value share in overall aquatic production (FAO, 2021b). The production of seaweeds requires a large amount of manpower and is often labour-intensive (Kunjuraman, 2017). As a result, it provides gainful employment and income opportunities to numerous households in coastal communities. In general, seaweed handling, distribution, processing and selling produce more revenue and employment (Zamroni, 2021). For instance, it was estimated that the seaweed sector in the Philippines employed between 100 and 150 thousand seaweed producers, 30 to 50 thousand local wholesalers, and over 20 thousand small dealers (Valderrama et al., 2013). India's coastline stretches over 7500 km with a diverse range of seaweed resources (Mantri et al., 2019). Seaweeds are abundant along the Tamil Nadu, Gujarat coasts, Lakshadweep, Andaman, and Nicobar Islands (Department of Fisheries, GoI). ICAR-Handbook of Fisheries and Aquaculture reported that there are 350 species of seaweeds in India, including 130 red seaweeds, 95 green seaweeds, and 125 brown seaweeds (Ayyappan et al., 2006). These seaweeds have significant potential across multiple sectors, such as agriculture, medicine, food, and cosmetics. The seaweed industry in India is a major employer of coastal residents. The seaweed farming, processing, and trade employ many

peoples of the country (Khan and Satam, 2003). Most of these individuals work in small-scale seaweed cultivation, although some large commercial farms were found in Tamil Nadu and Gujarat.

The Indian government acknowledges the potential of seaweed resources and has implemented measures to promote efficient and sustainable utilization in the industry. The National Fisheries Development Board (NFDB) has launched several programs to encourage seaweed cultivation and processing. In addition, a significant number of administrative and support positions were also produced by the seaweed-carrageenan business in government agencies and laboratories.

In recent years, there has been a growing interest in the commercial use of seaweed, particularly in aquaculture (Kim et al., 2019). Seaweed farming is an important component of aquaculture and can potentially revolutionize the industry. This book chapter explores the benefits of seaweed utilization and its potential applications in evolutionary aquaculture.

Seaweed Farming

Seaweed is a sustainable and renewable resource that has the potential to play a vital role in meeting the world's growing food demand. Seaweed farming is an environmentally friendly practice that requires no fertilizers or pesticides, and it improves the water quality by absorbing excess nutrients (Radulovich et al., 2015). This makes it an ideal crop for aquaculture. According to the United Nations Food and Agriculture Organization (FAO), the world's total seaweed production in 2020 was around 32 million metric tons, with China being the largest producer, accounting for approximately 60% of the global production (Msuya et al., 2022). Conversely, India produced around 0.32 million metric tons of seaweed in 2019, which is relatively less than its Chinese counterparts (Gajaria and Mantri, 2021). Seaweeds grow quickly, with some species growing up to 30 cm per day. This means that it can be harvested multiple times a year, providing a reliable source of income for farmers. Seaweed farming is already a major industry in some parts of the world, particularly in Asia, where it has been practiced for centuries. However, there is still a lot of work remaining for growth and innovation. Seaweeds have numerous biological activities such as antimicrobial, anti-obesity, anti-inflammatory, prevention of osteoarthritis, and neuroprotective (Khalid et al., 2018). Seaweeds are also highly nutritious, containing a wide range of vitamins, minerals, and antioxidants (Peñalver et al., 2020). It is a good source of protein and dietary fiber and is low in calories and fat (Rajapakse and Kim, 2011). As a result, seaweed is becoming increasingly popular as a food ingredient, particularly in Asian cuisine. It can be used in soups, salads, sushi rolls, and can also be dried and ground into a powder for use in the pharmaceutical and cosmeceutical industry (O'Connor, 2017). Researchers and entrepreneurs are exploring new ways to cultivate and harvest seaweeds and new applications for this versatile crop.

Types of Seaweeds

Seaweeds are classified into three major groups based on pigmentation: red, brown, and green. Each of these groups contains numerous species with unique properties.

A) Red Seaweed

Red seaweeds, also known as Rhodophyta, are the largest group, containing over 6,000 species (Carpena et al., 2022). It is named after its distinctive red pigmentation due to the presence of the pigment phycobilin. Red seaweeds contain photosynthetic pigment chlorophyll a and d. red seaweed is commonly used in food, cosmetics, and medicine. One of the most popular species of red seaweed is Nori (*Porphyra* sp.), which is used in sushi preparation (Nisizawa, 1987). It is also

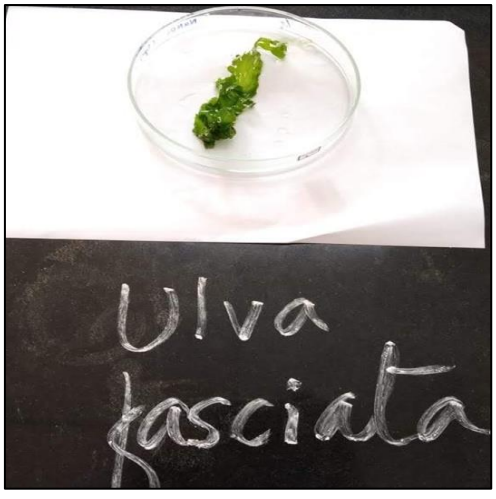
used in other Japanese dishes, such as miso soup and onigiri. Other Red seaweeds, such as dulse (*Palmaria palmata*) and laver (*Porphyra* sp.), are also used in food, particularly in Europe and Asia. Red seaweeds are also used in cosmetics because they moisturize and protect the skin. It contains polysaccharides that can enhance the skin's natural barrier function and protect against environmental damage (Shafie et al., 2019).

(Photo by: Swapnil N.)

B) Green Seaweeds

Green seaweed, also known as Chlorophyta, is named after its green pigmentation due to chlorophyll a and b (Chen and Roca, 2018). It contains over 7,000 species and is commonly used in food, medicine, and cosmetics (Sahoo, 2010). Green seaweeds play an important ecological role as primary producers, providing food and habitat for many marine organisms. They also contribute to coastal ecosystems by providing oxygen and filtering out pollutants (Mourad and Azim, 2018).

Common green seaweed types include sea lettuce, *Ulva lactuca*, and *Codium fragile*. These species can be used in various ways, such as in food products, fertilizer, and cosmetic products (Pereira et al., 2020). Despite their ecological importance and potential uses, green seaweeds can also become problematic when they overgrow, leading to harmful algal blooms and negatively impacting marine ecosystems.



(Photo by: Prakash)

C) Brown Seaweeds

Brown seaweed is a type of marine algae that belongs to the phylum Phaeophyta, containing photosynthetic pigment chlorophyll a and c (Baweja et al., 2016). They also contain fucoxanthin pigment, which is responsible for the characteristic brown colour (Din et al., 2022). It is typically found in cold temperate waters and can grow to substantial lengths of up to 60 meters. Brown seaweed is an essential iodine source for maintaining a healthy thyroid gland (Smyth et al., 2021). It is also rich in minerals such as calcium, iron, and magnesium and contains various bioactive compounds with antioxidant and anti-inflammatory properties (Nazarudin et al., 2021). Brown seaweed has been traditionally used in Asian cuisine, and its extracts are now used in various ways due to its numerous health benefits. One of the most popular brown seaweeds is Kelp is also used in supplements and cosmetics due to its high nutrient content and anti-inflammatory properties (Hamid et al., 2015). Other brown seaweeds, such as Wakame and Hiziki, are also used in food, particularly in Japan.

(Photo by: Prakash)

Cultivation and Harvesting Techniques

There are several different techniques for cultivating and harvesting seaweeds, each with its advantages and disadvantages. One common method is to attach seaweeds to ropes or lines which are then suspended in the water. The seaweeds are allowed to grow on the ropes and then harvested by cutting the lines and bringing the seaweeds to shore (Chennubhotla et al., 1987). Another method is cultivating seaweeds on rafts or platforms anchored to the seabed. This method is particularly useful for farming larger species of seaweeds, as it allows for greater control over the growing conditions. Seaweeds can also be grown in tanks or ponds, although this method is less common (Mohamed, 2013).

Once the seaweeds have been harvested, they can be processed in a variety of ways, depending on their intended use. It can be dried, ground into a powder, or processed into other products, such as food additives or pharmaceuticals.

Potential Applications of Seaweeds

Seaweed has an extensive range of potential applications in agriculture, food, and medicine. One of the most promising applications of seaweeds is in the aquaculture. Seaweeds can be used as a feed supplement for farmed fish and shellfish, providing a source of essential nutrients such as vitamins, minerals, and protein (Morais et al., 2020). Seaweeds can also be used as a natural fertilizer for crops, helping to improve soil health and increase yields (Nanda et al., 2020). It is a good source of protein and dietary fiber and is low in calories and fat. It can be used in soups, salads, and sushi rolls, and it can also be dried and ground into a powder for use in supplements and health products.

Over the last few years, alternatives to antibiotics have been sought, and seaweed is one of the available solutions (Pérez et al., 2016). Seaweed extracts are high in important bioactive compounds with a wide range of biological actions, including anti-inflammatory, antiviral, and antibacterial properties (Sakthivel and Devi, 2019). Seaweed extracts are also used in cosmetic products, as they have moisturizing and anti-inflammatory properties.

Challenges and Opportunities

Seaweeds present exciting opportunities and a promising future perspective in various industries like food, cosmetics, pharmaceuticals, and biofuels. As a sustainable and renewable resource, seaweeds have the potential to contribute to the global economy and address some of the world's most pressing environmental challenges, such as climate change and food security. While seaweed farming has many advantages, several challenges must be addressed for the industry to reach its full potential. One challenge is the lack of infrastructure for processing and marketing seaweed products. In many parts of the world, seaweeds are still considered a low-value product (Nakhate and Meer, 2021).

Conclusion

Seaweed utilization is an imperative pathway of evolutionary aquaculture. Its sustainability, versatility, and nutritional value make it an attractive crop for farmers and entrepreneurs. As the world's population grows and concerns about food security and environmental sustainability become more pressing, seaweed farming will likely become an increasingly important component of our global food system.

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SELF-PROPELLED RIDING TYPE WETLAND DIRECT RICE SEEDER

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Abstract
Manual transplanting, a pre-dominant practice in almost all the paddy growing areas in India, is laborious, burdensome, and has many expenses on raising, settling, and transplanting nursery. The transplanting process's limitations motivated the replacement of conventional paddy transplanting methods. For this seeder, 4.4 hp horizontal type air cooled four stroke single cylinder diesel engine was used as power source. Eight hoppers with cup type seed metering mechanism to pick and drop the seeds in the puddled field. From the evaluation it is found that this machine is capable of sowing pre-germinated seed of 1.92 ha/day.

Introduction

Direct seeding is an age-old practice of paddy cultivation in India, particularly in rain fed areas, where farmers totally eliminate seedling preparation in nursery and the required transplanting operation. Rice is direct-seeded by essentially two methods (dry and wet seeding) based on the physical condition of the seedbed and seed (pre-germinated or dry). Dry seeding is practiced in rainfed lowland, upland, and flood-prone areas. Wet seeding is a common practice in irrigated areas, and it is further subdivided into aerobic wet seeding, anaerobic wet seeding, and water seeding, based on the level of oxygen in the vicinity of the germinating seed or the depth of floodwater at seeding. Seeds may be broadcast or sown in rows on dry/ moist/puddled soil, whereas only broadcasting is used for seeding on water.

Need of self-propelled direct rice seeder

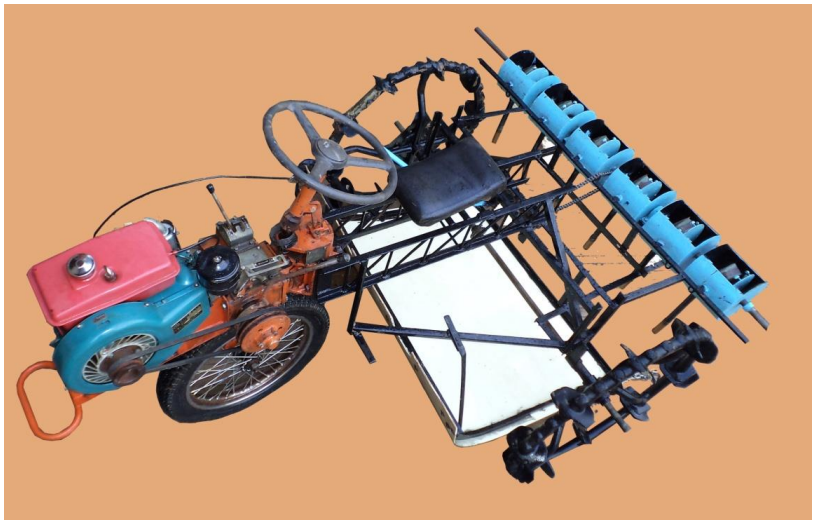
Transplanting rice seedlings is a labor-intensive and costly operation that could be made more efficient with direct seeding, potentially reducing labor needs by over 20% in terms of working hours. Although several designs of manual and bullock-drawn drum seeders have been created for line sowing, using them on puddled fields is difficult due to the significant physical effort required, making it a demanding task. Direct dry seeding, on the other hand, is an excellent method, especially in rainfed field conditions. The use of direct seeding method further increases income by eliminating cost of excessive seeds, labor for pulling and transplanting, reduce stress on pulling resulting too much higher percentage of germination and survival rate.

Development of self-propelled direct paddy seeder

To overcome the above said problem, a Self-propelled riding type wetland direct rice seeder has been developed for sowing pre-germinated paddy seed in the puddled field. The seeder can be operated by a 4.4 hp horizontal type air cooled four stroke single cylinder diesel engine. The gear boxes used in this machine are taken from the transplanter of riding type. Rubber moulded iron lugged wheels are used as ground wheel. The ground wheels are fitted at both end of the axle. The ground wheel

drive is transmitted to the countershaft fitted at the rear side of the lower frame through chain sprocket arrangement.

An opening is made in the upper part the seed drum for storing the pre-germinated seeds at the time of operation. Funnel and seed disc with cup feed is placed inside the seed drum for effective falling of seeds from the seed drum to the field. The eight seed drums are bolted to the "L" angle in order to prevent from rotation of the drum during operation. The spacing between seed drums is adjustable from 250 to 300 mm. The funnel receives the seeds from the cup and the seeds are dropped on the puddle soil by gravitational force. Float is made of PVC and placed in between the two wheels of the machine for leveling the puddle field. The rear end of the float is attached to "L" angle of the seed drum with the help of a chain for automatic depth adjustment according to the field.



Operational view of the self-propelled direct paddy seeder

Conclusion

The developed self-propelled wetland direct rice seeder is evaluated in the actual conditions to measure the field capacity of the direct paddy seeder. The seeder is an eight-row machine and is capable of sowing pre-germinated seed of 1.92 ha/day. The seeding machine costs around Rs.90, 000.

The cost of seeding by this machine is Rs.635/ ha. The machine is capable of sowing the pre-germinated rice @ of 9 kg/ha. The cost of manual transplanting comes to Rs.7000/ha whereas for machine transplanting comes to Rs.10000/ha per hectare inclusive of seeds.

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INTEGRATION OF PLANT-BASED PROTEINS INTO AQUACULTURE DIETS FOR SUSTAINABLE FISH GROWTH

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Abstract
Aquaculture, the fastest-growing sector of aquatic animal production, plays an essential role in addressing global food security and nutritional needs. Plant-based proteins are utilized as partial or complete fishmeal replacements to reduce feed cost. However, these proteins can adversely affect and alter growth and feed performance, carcass composition and indices, and gut and hepatic health. This review discusses the use of seven plant-based proteins: namely, soybean, copra, pea, corn, palm kernel, microalgae, and seaweed as a aquafeed. Hindrances to the use of plant-based proteins as a main dietary protein are limiting amino acids, presence of anti-nutritional factors, and the competition between its demand as human food and as animal feed.

Keywords: Aquatic animal, Aquafeed, Plant protein sources, Anti-nutritional factor

Introduction

Traditional aquaculture diets frequently use fishmeal and fish oil from marine species that caught in wild environments, creating problems from an ecological, moral, and financial standpoint. Different processing methods are employed to produce several types of plant-based proteins. Processed plant-protein types, when utilized as an aquafeed ingredient, vary in its effect on the performance, hemato-immunological parameters, and gut and hepatic health. Importantly, the use of plant-based proteins in aquaculture has the potential to support the sustainability of the sector by minimizing dependence on limited marine resources and reducing ecological footprint.

Effect of dietary components on fish health

The importance of proper nutrition in maintaining fish health and normal growth has long been acknowledged. In intensive culture, artificial diets made from different feedstuffs serve as the main source of nutrition. Prepared diets can expose fish to additional substances that could either have a positive or negative impact on their health in addition to providing the essential nutrients needed for normal physiological function (Hardy & Kaushik 2021).

Dietary plant-based proteins for fish

Nutrition is defined as the interaction of a nutrient with living organisms which includes feed composition, ingestion, digestion or energy liberation, waste elimination, and nutrition required for maintenance, growth, and reproduction. Energy from food and feedstuffs is necessary for the growth, reproduction, and general health of aquatic organisms. Insufficient amount of diet can cause diseases and stunted growth. Aquaculture often relies on various plant-based protein sources as alternatives to fishmeal, which can be expensive and environmentally unsustainable. These plant-based protein sources provide essential amino acids and serve as a crucial component of balanced fish diets. Some common types of plant-based protein sources used in aquaculture.

Soybean meal (SBM)

The vegetable-protein source that replaces fish meal most frequently in practical diets is soybean meal. Soybean meal (SBM), which has a high protein content, high digestibility, and a generally well-

balanced amino acid profile, is a common feed ingredient for many aquaculture species. Soybeans are high in protein (44-50%), and they include all the necessary amino acids that fish need. Feeds for many different fish species, such as salmon, trout, tilapia, and catfish, frequently contain soybean meal. Since it has a balanced profile of essential amino acids, it is regarded as a healthy source of protein for fish. But in comparison to the needs of some fish species, soybeans may not contain as much methionine or lysine as other amino acids. Therefore, to meet the fish's nutritional needs, further amino acid supplementation might be required. Anti-nutritional elements found in soybeans, such as phytic acid and trypsin inhibitors, can obstruct fish's ability to digest and absorb nutrients. Due to its widespread cultivation and easy accessibility, it is an affordable source of protein for fish meals. Its versatility in forms (meals or pellets) makes it simple to use into fish diet formulations (Iqbal *et al.,* 2022).

Corn gluten meal

As a byproduct of processing corn, corn gluten meal has a high protein content. This is especially beneficial for fish species that are herbivorous and omnivorous in their diets. Certain fish species can use it as a source of protein. Corn gluten meal has between 60% and 70% protein. Certain fish species, such as catfish and tilapia, are comparatively good at tolerating and digesting plant-based proteins like maize gluten meal. Carnivorous fish species, like trout and salmon, on the other hand, may not be as adept at using plant-based proteins and instead have a greater need for animal-based proteins. Due to its high protein content and excellent digestibility for a variety of fish species, maize gluten meal can help fish grow at healthy rates by facilitating effective nutrient absorption and utilization. A healthy supply of amino acids, like as methionine and lysine, which are vital for fish growth and development, can be found in maize gluten meal. On the other hand, it lacks some important amino acids, such as histidine and tryptophan.

Wheat gluten

Wheat gluten is made from wheat and has a high-grade protein content. It serves as a source of vital amino acids for aquaculture feeds. Many fish species, such as carp, tilapia, and marine finfish, can be fed wheat gluten. Like maize gluten meal, wheat gluten can also be utilized as a source of protein for fish. Gluten proteins make up the majority of wheat gluten, which is a byproduct of processing wheat. It is well-known for having a high protein level, usually between 70% and 80%. It is crucial to keep in mind that different fish species have varying nutritional needs and capacities for metabolizing plant-based proteins when thinking about using wheat gluten as a source of protein for fish. Certain fish, like carp and tilapia, can use wheat gluten as a useful source of protein and have a comparatively high tolerance for plant-based proteins. However, carnivorous fish species, such as salmon or trout, may not gain as much from plant-based protein sources and instead have a greater need for animal-based proteins.

Canola meal

A byproduct of extracting oil from canola seeds is canola meal. It is a valuable source of protein and replaces fishmeal in aquaculture feeds. Canola meal has been successfully fed to salmonids, tilapia, and other fish species. Among the necessary amino acids that are plentiful in canola meal and are vital to fish growth and development are methionine, lysine, and cysteine. Protein content in canola meal is normally between 36% and 40%. Canola meal has a well-balanced amino acid profile, while possibly having less tryptophan and threonine than other meals. Canola meal is an important source of protein because it provides vitamins, minerals, and fatty acids that are important for fish growth

and development. Fish health and vitality are also enhanced by the presence of these nutrients. Canola meal also includes lipids, carbs, and other elements that increase the caloric value of the diet.

Sunflower meal

A substance high in protein that can be utilized in aquaculture is sunflower meal. It may, however, contain less protein (28% to 35%) than some other plant-based protein sources. Sunflower meal is a possible source of protein for fish feeds; nevertheless, its usefulness will vary depending on the type of fish and their specific dietary requirements. Sunflower meal is beneficial as a protein source for fish species like tilapia and carp that can digest and use plant-based proteins. Sunflower meal is beneficial as a protein source for fish species like tilapia and carp that can digest and use plant-based proteins. Carnivore fish species need a greater need for animal-based. There are comparatively few important amino acids, such as lysine and methionine, in sunflower meal.

Cottonseed meal

It is inexpensive, high-digestible, high in protein, and promotes the growth of fish species. Nonetheless, the presence of certain anti-nutritional components might limit its application in fish diets. Cottonseed meal is rather an acceptable source of protein for fish because it normally includes 40% to 50% protein. Cottonseed meal can be beneficial as a protein source for fish species like carp or tilapia that can handle and digest plant-based proteins well. Gossypol levels can be harmful to fish health, so it is important to choose premium cottonseed meal with minimal amounts. Cottonseed meal also contains dietary fiber, which is advantageous for fish digestion.

Rice polish

Fish can be fed rice polish, sometimes called rice bran, as a source of protein. A byproduct of milling rice, rice polish is packed with nutrients such as proteins, carbs, lipids, vitamins, and minerals. Typically, rice polish has a protein content of 12% to 18%. It is crucial to remember that rice polish could not have the same level of protein quality or balanced amino acid profile as other protein sources like fish or soybean meal. Moreover, rice polish has lipids, carbs, and other elements that can raise the energy level of fish meals. It also contains nutritional fiber, which is beneficial to fish's digestive system.

Conclusion

Global aquaculture heavily depends on fishmeal for aquafeed production. However, its price has continually inflated due to the increased demand for fish and fish products, which in turn, has immensely impacted the market price. Nowadays, various plant-based proteins are used partially or completely to replace the fishmeal to reduce feed costs. In aquaculture farming and industry, feeding accounts almost 50% of the total production costs (Mzengereza *et al.,* 2014). The protein source of aquafeeds accounts as one of the most expensive feed component. Fishmeal is the gold standard protein source due to its balanced amino acid and nutrition content, which is favourable for proper fish growth and development. Fishmeal is an industrial product made from wild-caught fish and fish by-products. Plant-based protein diets for aquafeeds have long been recognized to be inferior to fishmeal because of insufficient amino acid profile, lower palatability, and presence of anti-nutritional factors (ANFs) that affect the overall cultured fish performance. However, several studies have shown that plant-based protein diets such as Soyabean meal, corn gluten feed and cottonseed meal are superior to fishmeal in terms of cost-benefit analysis.

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PRECISION APICULTURE: A WAY FORWARD IN HONEYBEE COLONY MANAGEMENT

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Abstract

Precision beekeeping is an approach to apiculture management that relies on keeping an eye on individual colonies of bees in order to reduce resource usage and increase bee productivity. It can be classified as a subset of precision farming. The three stages of precision beekeeping implementation are data gathering, data analysis, and application. Measurements are taken from the environment and bee colonies during the data collection phase. The data analysis phase uses established models and expert knowledge in conjunction with measurement data to draw conclusions about the behavior and activity trends of bee colonies. During the application phase, choices are made and steps are completed to improve apiary performance based on data analysis. Recently, researchers have been more interested in this approach because of its potential effects on the environment. The bee colonies under studies are categorized according to the weight, internal temperature, relative humidity, flight activity, sounds and vibrations, and gases production as well as the internal and external parameters of the hive, which are further influenced by wind speed, rainfall, and ambient temperature. The study on precision apiculture also need to consider the negative consequences of using sensors on bees, as well as their economic importance, and the use of geographic information system technologies in beekeeping.

Introduction

Preserving biodiversity globally is perhaps one of the greatest issues of this century and perhaps the next. In this context, a lot of attention has been paid to insects, whose decline has been documented on both a local and worldwide scale. Insects perform a variety of useful tasks, one of which is pollination. In fact, pollinators have the power to increase the yield of 70% of the world's most significant crop species and contribute to 35% of the world's food supply. Because they play a crucial role in pollination, honeybees and beekeepers are valuable resources for the planet. Humans are able to safeguard the well-being and longevity of the honeybee populations. The recent technical breakthroughs in beekeeping have been developed to effectively manage the apiary for honey production by considering genetic, physiological, ethological, nutritional, and pathological factors. In precision apiculture, mainly two factors should be taken into consideration, external and internal factors, which are described below:

Internal factors:

Temperature

The most important factor is the observation of bee colony temperature. These days, monitoring bee colonies with temperature probes appears to be the easiest and least expensive method available. The inexpensive expenses associated with precision beekeeping include temperature measurement, data collection, processing, and transmission in beekeeping. Several techniques and

technologies can be used to monitor the temperature of a bee colony, which includes manual temperature readings, readings from various loggers, and buttons; sensor networks that are wired; network of wireless sensors and infrared imaging. The following colony parameters can be identified with the use of temperature data: death, swarming, brood raising, broodless condition, etc. In the vicinity of the brood, bees maintain a temperature of about 34±1.5ºC.

Weight of the hive

A hive's weight gives valuable information about the size and activity of the colony. For instance, a rise in weight indicates honey production and population growth, whereas a fall in weight may indicate wintertime honey consumption, but at other times it may be related to swarming or mortality events. The following are some of the parameters that can be determined from colony weight, (a) the presence of nectar flow during the foraging seasons, (b) feeding during times when foraging is not possible (c) the development of swarming occurrences brought on by a drop in weight, and (d) approximations of the forager population. There are two methods for determining the colony's weight: 1) automated calculations using commercial scales and 2) manual measurements of weights. There is a 300-500 g reduction when the bees leave to forage; but, as they return with full of pollen and nectar, the weight progressively rises until shortly before dusk. Wind and precipitation are two meteorological variables that can affect the weight of the hive analysis results. In order to solve the issue of the hive wood's moisture absorption, it is advised to use polystyrene hives as an alternative, and avoid accumulation of empty hives in the same environment.

Sound

One can use auditory signals and audio processing methods to estimate the behavior of bees. Although various tools and techniques for sound analysis have been created, industrial beekeeping does not frequently use them. A fully automated and non-invasive approach may identify and track a collection of statically independent instantaneous vibration signals of honey bees in real time by installing a simple transducer on the outside wall of the hive. Queen bees release a series of brief pulses at a frequency of around before flickering. They emit sounds at different frequencies. 350 Hz as soon as they emerge, and on the first day, between two and four days after birth, they produce sounds at a frequency of 400 Hz.

Gases

Regular observation of gas accumulation should be carried out in beehives. Measuring carbon dioxide (CO_2) is crucial for examining bee behavior. It is related to bee metabolism because a change in its respiratory emission corresponds to a bee's typical metabolic heating. Certain gases can be used to detect diseases that affect honeybees. For example, the presence of *Paenibacillus larvae*, the causal organism of American foulbrood, may be indicated by the higher levels of valeric acid, caprylic acid, and isocarprylic acid.

External factors

Windspeed

Insect flight is an expensive endeavour, and the presence and strength of the wind significantly affects this cost; for example, bee populations decrease as wind speeds rise. A mere 2.75 m/s wind speed results in a 37% reduction in floral visits. The production of honey is correlated with wind measurement. A reduction in honey yield was noted during wind peaks exceeding 4 m/s.

Rainfall

On rainy days, when than ambient relative humidity is more than 80%, the bees remain dormant. Honey bees spend less time foraging because rain keeps them inside the hive. Bees can still fly during small showers, but not in periods of intense precipitation. Pollen is washed away by frequent and intense rainstorms, and flowers require varying degrees of heat in order to generate nectar.

Geographic information system

Apiary locations are often chosen by beekeepers using their experience, yet occasionally the site may not be ideal for bee colonies. The choice of where to locate an apiary is just one of the many facets of beekeeping where a geographic information system might be used. Beekeepers can choose and plan the foraging places with significant assistance from the provided solution and interactive digital map. GIS vegetation and colony production Interaction between bee plants is crucial to colony productivity. The appropriateness of land for beekeeping is limited by the lack of nectar and pollen sources as well as a shorter flowering time. GIS and organic beekeeping call for the use of only natural foundations and organic methods for producing organic goods from bee colonies. One of the challenges to the growth of beekeeping is the frequency of pests and diseases that affect bees. Aside from mites, additional bacterial, fungal, and viral infections can affect honey bees in both their adult and juvenile phases of life. In GIS and honey bee mating, partners are found in drone aggregation locations and in the air. The identification of Drone Congregation Areas (DCAs, an aerial location where drones congregate to engage in mating with queen bees) is very beneficial to beekeepers, especially those who are producing mated honey bee queens, as GIS can be used to study the geographical and environmental elements in a DCA and subsequently anticipate possible ones in different locations.

Remote sensing

Precision apiculture involves using advanced technologies to monitor and manage beekeeping more effectively. Remote sensing technologies can enhance this by providing real-time data on hive condition such as temperature, humidity and hive weight. Sensors and IoT (Internet of things) devices can be deployed in and around hives to gather this information, which helps in optimizing hive health, improving honey production, and detecting problems early. This approach can lead to more efficient and sustainable beekeeping practices.

Conclusion

Precision apiculture represents a significant advancement in beekeeping practices, combining traditional methods with modern technology. By leveraging data from sensors, imaging beekeepers can make more informed decision, improve hive management and optimize resources. This approach not only support better honey production but also contributes to the overall health of bee population, which is crucial for both agriculture and biodiversity. The continued development and adoption of precision apiculture techniques are likely to play a key role in addressing the challenges facing beekeeping in the future.

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SOURSOP: ECONOMIC IMPORTANCE AND ASSOCIATED POSTHARVEST MANAGEMENT PROBLEMS

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Summary

There are quite a number of highly useful but underutilized crops in Nigeria. Soursop belongs to this category of plants. This write-up is focused on its medicinal uses and problems of handling. Its pharmacological properties include antiulcer, anticancer, antidiabetic and antibacterial. These attributes are due to heavy presence of bioactive compounds in it. However, like many other common tropical fruits, its value chain is faced with huge spoilage due to high moisture content and susceptibility to microbial attack. For optimal utilization of Soursop fruit, these numerous identified gaps should be addressed. The use of physical technique, cooling technology, modified atmosphere packaging, ethylene inhibitors and edible coatings might be a useful alternative in enhancing the quality and marketability of this fruit.

Introduction

Soursop (*Annona muricata*) belong to *Annonaceae* family and *Annona* genus (Höferl *et al.*, 2013). Largely grown in tropical and subtropical regions, it has edible fruit which is produced almost all year round. The fruit has soft thorn-like skin that consists juicy, sweet-scented and tart pulp (Moghadamtousi *et al.*, 2015). Soursop fruit consist of core (4%), seeds (8%), peel (20%), and edible pulp (67%).The edible pulp is rich in carbohydrate, protein, water, vitamins B1, B2, and C, fibre and non-reducing sugar. It is rich in minerals like calcium, phosphorus, potassium, magnesium, copper, iron and sodium, where potassium is most abundant. More than 212 phytochemicals are present in soursop (Afzaal *et al*., 2022), the major ones are; acetogenins, flavonoids, alkaloids, vitamins, carotenoids, essential oils, amides, and cyclopeptides (Coria-Téllez *et al.,* 2018). Of all the major compounds present in the fruit, acetogenins are the most abundant while the most abundant alkaloid compounds are reticuline and coreximine (Mutakin *et al*., 2022).

Acetogenins are a class of phytochemicals referred to as polyketides. The major acetogenins present in soursop are annomuricins and annonacin (Mutakin *et al*., 2022). They exhibit cytotoxic properties on certain cells which explain their anticancer activities. Likewise, coreximine is cytotoxic, antiparasitic and anti-inflammatory while reticuline has analgesic, anti-inflammatory and antioxidant properties (Afzaal *et al*., 2022).

(a) Soursop leaves (**b**) Soursop fruit (Source: Mutakin *et al*., 2022)

Culinary Uses

Soursop pulp is made into fresh fruit juice either alone or as ingredient in a mixed fruit juice. It is used to make candy which is called DodolSirsak in Indonesia. It is eaten as ripe fruit, used to make fruit juices, ice cream or smoothies in countries like Philippines, Ghana and Nigeria. The leaves are boiled as tea and sometimes used to tenderize meat.

Tradomedicinal Uses

Every part of soursop is conventionally usedto treat a number of diseases namely; malaria, gastrointestinal problems, diabetes, cancer and parasitic infections. In sub-saharan Countries, the roots, bark, and leaves are used for curing diabetes, headaches, insomnia, liver diseases, cystitis, hypertension, helmintic and parasitic infections as well as heart-related diseases. They are used as sedative, smooth muscle relaxant, to combat dysentery and inflammation. The leaves are cooked and used to treat abscesses and skin diseases. The pulp of the fruit is used to treat skin rashes, rheumatism, arthritis, fever, neuralgia and diarrhoea as well as facilitate lactation (Mutakin *et al*., 2022).

Pharmacological Activities

As reported by (Mutakin *et al*., 2022) from several scientific studies cited, soursop has, but not limited to the following pharmacological activities:

- Antiulcer agent; soursop leaves showed antiulcer activity by activating synthesis of prostaglandin which is a gastro protector while suppressing gastric mucosa aggressive factors. Its ethyl acetate extract exhibited antiulcer activity by preventing gastric wall damage and scavenging ROS. Also, by down regulating Bax, MDA, and up regulating Hsp70, superoxide dismutase, catalase, nitric oxide, glutathione, Prostaglandin E2 and glycogen.
- Anticancer agent; extracts from distinct parts of Soursop exhibit anticancer property through several mechanisms such as: Annomuricin E mediated inhibition of HT-29 cell growth and activation of pro-apoptotic factors caspase-3, caspase-7, and caspase-9, inhibition of the human leukemia cell line HL-60 proliferation, reactive oxygen species (ROS) generation, and the arrest of G0/G1 cell leading to inhibition of cancer cell growth, initiation of apoptosis of cancer cells by amplifying the expression of caspase-3and caspase-9 and decreasing Bcl-2 expression, annonacin-mediated cell apoptosis which increases caspase-3 cleavage and DNA fragmentation.

- Antibacterial capacity; soursop extracts had antibacterial effect against both Gram+ and Gram- bacteria. The combination of its ethanolic extract with antibiotic treatment reduced the strength of multidrug-resistant *E.coli* and *S.aureus* strains. Also, its bioactive isolates (annonaine, liriodenirine, asimilobine, nornuciferine), attack the bacterial plasma and outer membranes leading to broad-spectrum antibacterial activity.
- Antihypertensive ability; soursop fruit extracts express antihypertensive property in vitro, via angiotensin-I-converting enzymes while its leaf extract express antihypertensive ability by blocking calcium ion channels (Adefegha *et al*., 2015).

Post-harvest Handling Problems of Soursop

Post-harvest handling of soursop is faced with various challenges in Nigeria which hinder efforts to extend the shelf life of the fruit and makes it difficult to be commercialized at international markets. These challenges include;

- **Microbial attack;** the impact of diseases caused by microbes on agricultural food crops has increased worldwide which had resulted to a loss of appreciable fruit quality (Moore *et al*., 2023). Some common diseases in soursop were found to be majorly those caused by fungi which include; dry rot, soft etc. caused by *Collecttrichum*, *Fusarium*, *Botrytis*, *Rhizopus Aspergillus* and *Penicillum* (Amusa *et al*., 2003; Moore et al., 2023). Report have shown the effects of microbial attack of soursop fruit to include reduction in carbohydrate and protein contents of the pulp while the activities of pathogenic fungi might result into production of secondary metabolites such as mycotoxins (Amusa *et al*., 2003).
- **Lack of proper storage facility**; storage facilities that are equipped with temperature and humidity control, properly ventilated with controlled stacking are unavailable to most farmers in the Country.
- **Poor packaging;** poor packaging of the fruit can lead to bruising, compression, deformation and exposure to insects and contaminants. All these damage the fruit physically, affect the appearance and overall quality of the produce leading to rejection.
- **Quality control issues;** Grading standards and quality control measures are not fully employed and adhered to hence variations in fruit quality, not meeting the safety and quality standard leading to rejection by consumers and at international markets.
- **Accessibility to markets;** soursop farmers face difficulties in accessing domestic and international markets as a result of the aforementioned points. This leads to limitation in economic potentials of the producers.
- **Awareness limitations;** farmers and other stakeholders have little awareness about the best international practices in post-harvest management of soursop. This is a major limitation that leads to huge loss that could have been avoided.

Improved Handling of Soursop

Among the factors responsible for high postharvest losses of soursop (25–35%) is inadequate knowledge about the practices (Jiménez-Zurita *et al*., 2017). Although the initial quality of the harvested soursop fruit cannot be improved by applying technologies during postharvest period, but it is possible to maintain it using appropriate conservation systems; such as adequate packaging, refrigeration system, controlled atmosphere storage or modified atmospheric storage systems andthe most used method is refrigeration, with which the shelf life has been extended for up to 8 days (Jiménez-Zurita *et al*., 2017; Alejandro *et al*., 2020). Soursop is climacteric fruit, therefore the

use of ethylene inhibitors to slow down ripening could be very useful in postharvest handling (Jiménez-Zurita *et al*., 2017). Other methods such as application of edible coatings or waxes could also help in improving the postharvest quality of this fruit.

Conclusion

Soursop has excellent marketing potentials, good taste for the consumers and other numerous culinary and medicinal uses. However, the rapid softening during postharvest period is one of the most critical problems that hinder the commercialization of this fruit. Application of appropriate techniques for postharvest management of soursop could minimize losses, enhance quality and increase marketability of the fruit both locally and internationally.

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HARNESSING ORGANIC MANURE FOR SUSTAINABLE STRAWBERRY FARMING: ENHANCING SOIL HEALTH AND YIELD

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Abstract

Strawberry farming requires careful nutrient management for optimal growth and sustainability. Organic manure, derived from natural sources like animal waste and compost, plays a vital role in enhancing soil fertility, improving water retention, and promoting beneficial microbial activity. This abstract explores the advantages of using organic manure in strawberry cultivation, including improved soil structure, enhanced nutrient availability, and long-term soil fertility. By reducing reliance on synthetic fertilizers, organic manure supports sustainable farming practices, promoting environmental health and reducing greenhouse gas emissions. Challenges such as quality control and application timing are also discussed. Overall, organic manure offers a sustainable, eco-friendly solution for achieving high yields and superior-quality strawberries while maintaining soil health for future agricultural productivity.

Keywords: Eco-friendly, Organic manure, Strawberry, Soil fertility.

Introduction

Fragaria x *ananassa* is the scientific name for the widely consumed cultivated strawberry. This species is a hybrid of *Fragaria virginiana*, which is native to North America, and *Fragaria chiloensis*, which is native to the Americas. *Fragaria* x *ananassa*, the cultivated strawberry, has the chromosomal number 2n = 8x = 56. This fruit, which is a member of the Rosaceae family, is distinguished by its vivid red colour, succulent flesh, and surface covered in tiny seeds. Strawberries are a European delicacy that has captured the imagination of cooks worldwide and are now a staple in a wide range of meals, from savoury salads and sauces to sweet treats like cakes, pies, and ice cream. Strawberries have a long history; their cultivation has been documented as far back as ancient Rome. Strawberries are a gourmet favourite and have a great taste, but they also have some health advantages. They are an excellent complement to any diet because they are high in fibre, antioxidants, and vitamin C. It is said that eating strawberries will strengthen the immune system, improve heart health, and facilitate better digestion. Strawberries are now farmed in many parts of the world, with Mexico, Spain, and the United States being the top producers. In India, the northern provinces of Jammu & Kashmir, Uttarakhand, Himachal Pradesh, and portions of Punjab are the main growing regions for strawberries. These areas' mild climate and appropriate altitude make them ideal for growing strawberries. Furthermore, minor strawberry production is practiced in several locations in Maharashtra and Tamil Nadu, usually in higher altitudes with milder temperatures.

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Benefits of Organic Manures for Improved Growth Characteristics and Fruit Quality

Plant growth: Organic Fruit is in high demand, making it very profitable per unit area. Because they enable plants to grow and develop sustainably, macro- and microelements are regarded as being extremely important. The creation of more runners and their branching was directly correlated with the amounts of manure applied, indicating that the use of stable manure boosted vegetative development. In strawberries, the stable manure also promoted vegetative development, but artificial fertilizers seemed to have the opposite effect.

Lower chemical exposure: Synthetic fertilizers, herbicides, and pesticides are used less frequently in organic farming methods. This promotes safer and healthier food production by lowering the amount of potentially hazardous chemicals that farm workers, and consumers.

Soil health: Using organic amendments like compost, green manure, and crop rotations, organic farming techniques aim to improve soil health. Improved water retention, nutrient cycling, and general soil health are the results of these techniques, which also increase soil structure, fertility, and microbial activity.

Flowering: Organic manures promote flowering in plants like strawberries by providing balanced nutrients, improving soil structure, enhancing microbial activity, reducing stress, and supporting long-term soil health, ultimately leading to better flower production and higher yields. Organic manures such as compost, manure, and organic fertilizers release nutrients slowly and steadily into the soil as they decompose. This provides a continuous supply of essential nutrients like nitrogen, phosphorus, and potassium, which are crucial for flowering and fruit development in plants.

Increasing root development: The herbaceous strawberry plant has very shallow roots, therefore it requires special attention in both growing technique and nutrients. The top six inches of soil contain over 90% of this crop's roots. Strawberries typically have two different kinds of roots: huge primary roots and little secondary lateral roots. As long as the soil temperature is higher than 45°F, rooting will occur.

Beneficial for runner development: In temperate regions with well-moistured soil, fertilizer, and an appropriate drainage system, strawberries can be multiplied quite readily by runners. However, in regions where temperatures exceed 400 degrees Celsius during the regeneration phase and at water logging sites, strawberry propagation becomes extremely complex. Organic manure boosts runner

development in strawberries by supplying essential nutrients, improving soil structure, stimulating root growth, reducing stress, enhancing plant health, and providing long-term benefits to the soil.

Diminished Environmental Impact: As organic manures come from natural sources, they usually have a lower environmental impact than synthetic fertilizers. Organic manures encourage sustainable agricultural methods that are good for the environment and human health by lowering chemical runoff and dependence on non-renewable resources.

Challenges and Considerations

Quality of Organic Manure: Not all organic manure is equal in nutrient content. Farmers must ensure that the manure is well-composted and free from contaminants or pathogens that could harm the strawberry plants.

Application Timing: Organic manure releases nutrients slowly, so timing the application is crucial. Applying it too late in the growing season may not provide immediate benefits while applying it too early might lead to nutrient leaching.

Soil Testing: Regular soil testing is essential to determine nutrient levels and adjust organic manure application accordingly. Over-application can lead to nutrient imbalances or excessive vegetative growth at the expense of fruit production.

Conclusion

Strawberries grown organically have several benefits for the environment and for consumers. Organic farming practices align with sustainability and stewardship concepts, as they enhance biodiversity and soil health while limiting exposure to synthetic pesticides and boosting health. In addition, farmers who use these practices have financial prospects because to the growing demand for organic goods. Organic strawberry growing stands out as a potential strategy that promotes health, environmental stewardship, and resilience in the face of challenges like climate change, as concerns about food safety, environmental impact, and long-term sustainability continue to grow.

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CAPACITY DEVELOPMENT OF FARMING COMMUNITY FOR PROMOTING NATURAL FARMING: KEY EFFORTS TOWARDS SUSTAINABLE AGRICULTURE

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ABSTRACT
The Indian government's focus on natural farming reflects a growing recognition of the need for sustainable agricultural practices that protect the environment, improve farmers' livelihoods, and ensure food security. Natural farming has become a significant focus for the Indian government in recent years, driven by concerns about the environmental impact of conventional agriculture and the need for sustainable farming practices. Promoting natural farming as a method that emphasizes sustainable practices, minimal use of synthetic inputs, and enhancement of ecological balance which requires a multifaceted approach involving extension strategies and supportive government policies. A comprehensive outline of strategies and policies that could be effective for promoting natural farming by enhancing the capacity building of the farmers. Government support through subsidies and financial support, regulatory framework, policy integration, incentivizing private sector involvement. tax benefits, land use policies etc. can also lead to increase the adoption of natural farming. Extension personnel can play a vital role in capacity building through education and training programs, technical support and advisory services, research and development, farmer networks and cooperatives, incentive programs, community engagement, promotion of natural farming techniques.

Key words: Capacity building, Extension strategies, farmers, Natural farming, Sustainable agriculture, government policies

Introduction

The Indian government's focus on natural farming reflects a growing recognition of the need for sustainable agricultural practices that protect the environment, improve farmers' livelihoods, and ensure food security. The Government of India has undertaken various initiatives to build the capacity of farmers and promote natural farming practices. Promoting natural farming—a method that emphasizes sustainable practices, minimal use of synthetic inputs, and enhancement of ecological balance—requires a multifaceted approach involving extension strategies and supportive government policies.

Capacity building refers to a process of change in which people, organizations and institutions improve their performance and refine, strengthen and adapt their capacity over time in response to changing circumstances. Capacity building for natural farming is an ongoing process that requires

collaboration, adaptation, and commitment from all stakeholders. By focusing on education, resource provision, networking, monitoring, support systems, and advocacy, the extension of natural farming practices can be more effectively achieved, leading to sustainable and resilient agricultural systems.

National Mission on Sustainable Agriculture (NMSA), Paramparagat Krishi Vikas Yojana (PKVY), National Organic Farming Research Institute (NOFRI), Zero Budget Natural Farming (ZBNF), Promotion of Farmers' Producer Organizations (FPOs) etc. are some key efforts and programs that government of India has undertaken to build the capacity of farmers and promote natural farming practices. Here's an overview of some key efforts and programs:

Zero Budget Natural Farming (ZBNF): This technique, promoted by government initiatives, emphasizes reducing the cost of cultivation by relying on locally available resources and reducing dependency on chemical fertilizers and pesticides. ZBNF uses methods like seed treatment with cow dung and urine, and natural pest control.

National Mission on Sustainable Agriculture (NMSA): This mission promotes sustainable agricultural practices, including natural farming. It provides support for soil health management, organic farming, and integrated farming systems.

Soil Health Management (SHM): Part of the NMSA, SHM focuses on improving soil health through the promotion of organic farming practices, balanced use of fertilizers, and other soil health management techniques.

Paramparagat Krishi Vikas Yojana (PKVY): A scheme specifically designed to promote organic farming. It offers financial assistance for transitioning to organic practices, including training and certification.

Training and Capacity Building Programs: The government organizes training programs and workshops for farmers to educate them about natural farming practices. These include the use of organic inputs, composting techniques, and integrated pest management.

National Organic Farming Research Institute (NOFRI): NOFRI conducts research on organic farming techniques and provides technical support and training to farmers.

Krishi Vigyan Kendras (KVKs): These are agricultural extension centers that offer training and support to farmers, including information on natural farming techniques and sustainable practices.

Pradhan Mantri Krishi Sinchai Yojana (PMKSY): Focuses on improving irrigation infrastructure and ensuring water availability for farming. While not exclusively for natural farming, improved irrigation supports sustainable practices.

Fertilizer Subsidy Schemes: Although primarily aimed at conventional farming, these schemes sometimes include subsidies for organic fertilizers, promoting their use.

Promotion of Farmers' Producer Organizations (FPOs): FPOs help farmers by providing a platform for collective action. They can play a significant role in promoting and implementing natural farming practices by pooling resources and sharing knowledge.

Agri-Tech Startups and Innovations: The government supports agricultural startups that focus on natural farming techniques and innovations. This includes funding and infrastructure support for technology-driven solutions in natural farming.

Training and Education: The government provides training programs and workshops to educate farmers about natural farming techniques and their benefits.

Support for Research: The government funds research institutions to explore and develop natural farming practices that are suitable for different agro-climatic conditions in India.

Innovation Centers: Establishment of innovation centers to support farmers in adopting and scaling up natural farming methods.

Farmer Producer Organizations (FPOs): Support for FPOs helps in aggregating produce from natural farming, which improves market access and bargaining power for small farmers.

Infrastructure Development: Investments are being made in infrastructure to support the distribution and marketing of produce, including certification and labeling systems.

Soil Health and Water Conservation: Natural farming practices contribute to soil health and water conservation, which are crucial for long-term agricultural sustainability.

Healthier Produce: By avoiding synthetic chemicals, natural farming aims to produce healthier food, which can benefit public health.

Extension Strategies for capacity development of farmers: Here's a comprehensive outline of strategies that could be effective:

1) **Education and Training Programs:**
   - **Farmer Workshops:** Conduct regular workshops and training sessions on natural farming techniques, including soil health, crop rotation, and organic pest control.
   - **Demonstration Farms:** Establish model farms that use natural farming methods to showcase successful practices and results.
   - **Online Resources:** Develop online courses, webinars, and tutorials that are accessible to farmers in remote areas.
2) **Technical Support and Advisory Services:**
   - **Extension Agents:** Deploy extension agents who are trained in natural farming to provide on-site advice and support.
   - **Hotlines and Support Centers:** Set up hotlines and support centers where farmers can get immediate help with issues related to natural farming.
3) **Research and Development:**
   - **Collaborative Research:** Encourage collaboration between research institutions, universities, and farming communities to develop and refine natural farming techniques.
   - **Field Trials:** Support field trials and pilot projects to test new practices and technologies in real-world conditions.
4) **Farmer Networks and Cooperatives:**
   - **Peer Learning:** Facilitate the creation of farmer networks and cooperatives where practitioners can share experiences, knowledge, and resources.
   - **Mentorship Programs:** Establish mentorship programs where experienced natural farmers can guide newcomers.
5) **Incentive Programs:**
   - **Certification Support:** Offer assistance with certification processes for organic and natural farming, including covering certification fees and providing guidance on meeting standards.

- **Financial Incentives:** Provide financial incentives such as subsidies, grants, or low-interest loans for farmers transitioning to natural farming methods.

6) Community Engagement:

- **Public Awareness Campaigns:** Run campaigns to raise awareness about the benefits of natural farming among the general public.
- **School Programs:** Integrate natural farming concepts into school curricula to educate future generations about sustainable agriculture.

These initiatives aim to empower farmers with the knowledge, resources, and financial support needed to transition to and sustain natural farming practices.

Conclusion

The successful promotion of natural farming relies on a coordinated approach that combines effective extension strategies with supportive government policies. By focusing on education, technical support, research, financial incentives, and infrastructure, along with creating a favorable regulatory and market environment, it's possible to encourage the widespread adoption of natural farming practices and achieve long-term sustainability in agriculture.

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THE USE OF HERBS IN POULTRY PRODUCTION: BENEFITS, CHALLENGES, AND APPLICATIONS

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Abstract

Herbal supplements have gained increasing attention in poultry production due to their natural growth-promoting, antimicrobial, and antioxidant properties. In India, rural and traditional farming systems have long relied on medicinal herbs for maintaining poultry health, particularly in antibiotic-free systems. This article explores the role of commonly used herbs in Indian villages, focusing on their benefits in enhancing immunity, improving growth performance, and maintaining gut health. Recent research highlights the effectiveness of herbs like *tulsi* (holy basil), *neem*, *amla* (Indian gooseberry), *ashwagandha*, and *kalmegh* (andrographis) in promoting overall poultry health. Challenges, such as variability in herbal efficacy and optimal dosage, are also discussed.

Keywords: Herbal Supplements, Poultry Nutrition, Immune Boosting, Antimicrobial Properties, Growth Promotion

Introduction

In Indian villages, traditional knowledge has long emphasized the use of herbs in poultry farming for disease prevention and growth promotion. As the poultry industry moves away from synthetic antibiotics due to rising concerns about antimicrobial resistance, there is renewed interest in these ancient practices. Herbal supplements derived from locally available plants offer a sustainable, cost-effective solution, especially in rural areas where access to commercial feed additives may be limited. This article delves into the potential of herbs in Indian poultry production, particularly focusing on common herbs used by farmers in India's rural communities.

Commonly Used Herbs in Poultry Production in India

1. Tulsi (*Ocimum sanctum* or Holy Basil)

- **Immunomodulatory and Antimicrobial Effects**: Tulsi, or holy basil, is revered in India for its medicinal properties. It has strong antimicrobial and anti-inflammatory effects, helping poultry resist infections and reducing inflammation in tissues. Research by Prakash et al. (2021) shows that tulsi supplementation improves immune responses in broilers, increasing disease resistance.
- **Improved Growth Performance**: Supplementing poultry feed with tulsi has been shown to improve growth rates by enhancing digestion and nutrient absorption. Studies have reported increased feed intake and weight gain when tulsi is incorporated into broiler diets (Soni et al., 2022).

- **Antioxidant Properties**: Tulsi contains high levels of antioxidants, such as eugenol, which protect cells from oxidative stress. This is particularly beneficial in hot climates or during periods of stress.

2. Neem (*Azadirachta indica*)

- **Antimicrobial and Antiparasitic Effects**: Neem is widely used in Indian villages for its antimicrobial, antifungal, and antiparasitic properties. It has been effective in reducing the incidence of diseases such as coccidiosis and salmonella infections in poultry. Neem's bioactive compounds, like azadirachtin, act as natural insecticides, keeping parasites in check (Chaudhary et al., 2023).
- **Improved Gut Health**: Neem improves gut health by promoting beneficial bacteria while suppressing harmful pathogens. A study by Yadav et al. (2022) demonstrated that neem leaves in poultry diets improved gut microbiota and reduced the incidence of gastrointestinal diseases.
- **Anti-inflammatory and Immune-Boosting Effects**: Neem also possesses immune-modulating properties, enhancing the immune response and reducing inflammation in the gastrointestinal tract.

3. Amla (*Phyllanthus emblica* or Indian Gooseberry)

- **Antioxidant and Immune-Boosting Effects**: Amla is one of the richest sources of natural vitamin C, which plays a crucial role in enhancing immunity and protecting against oxidative stress. In poultry, amla supplementation boosts the immune system, increasing resistance to infections (Sharma et al., 2023).
- **Growth Performance**: Amla improves digestion and nutrient absorption, contributing to better growth rates and feed efficiency in poultry. It also helps in reducing mortality rates, especially during times of stress or disease outbreaks.
- **Liver Health**: Amla has hepatoprotective properties, which support liver function and detoxification. This can lead to improved overall health and performance in poultry (Mishra et al., 2022).

4. Ashwagandha (*Withania somnifera*)

- **Adaptogenic and Stress-Relieving Properties**: Ashwagandha, known for its adaptogenic properties, helps poultry manage stress, especially during heat stress or transportation. Stress is a significant factor affecting growth performance and immune function, and ashwagandha helps mitigate these effects (Kumar et al., 2023).
- **Immune Support and Antioxidant Effects**: Ashwagandha enhances the immune system by boosting antibody production and increasing the activity of immune cells. It also provides antioxidant protection, reducing oxidative damage to tissues.
- **Improved Growth and Health**: Ashwagandha has been shown to improve weight gain and feed efficiency in broilers when added to their diets, making it a valuable addition in rural poultry systems.

5. Kalmegh (*Andrographis paniculata*)

- **Antimicrobial and Antiviral Properties**: Kalmegh, commonly known as the "king of bitters," is widely used in Indian traditional medicine to treat infections and fevers. In poultry, it has shown antimicrobial and antiviral properties, reducing the incidence of bacterial and viral diseases (Rao et al., 2023).

- **Liver Health and Detoxification**: Kalmegh supports liver function and detoxification, which is essential for overall health and disease resistance in poultry.
- **Growth Promotion**: Kalmegh has been shown to improve feed intake and weight gain in broilers, enhancing overall growth performance and reducing mortality.

6. Garlic (*Allium sativum*)

- **Antimicrobial and Antiparasitic Effects**: Garlic has been used for centuries for its antimicrobial properties, largely due to its sulfur-containing compounds such as allicin. In poultry, garlic can inhibit harmful bacteria and parasites, improving gut health and reducing the need for antibiotics.
- **Immune System Enhancement**: Garlic stimulates the immune system by enhancing the activity of white blood cells and promoting the production of antibodies. Studies by Sadeghi et al. (2022) demonstrated that garlic supplementation improved the immune response in broilers and reduced mortality rates.
- **Antioxidant Properties**: The antioxidant activity of garlic helps mitigate oxidative stress, which is particularly beneficial in hot climates or during disease outbreaks.

7. Turmeric (*Curcuma longa*)

- **Anti-inflammatory and Antioxidant Effects**: Turmeric contains curcumin, a potent antioxidant and anti-inflammatory compound that protects tissues from oxidative damage and inflammation. Its inclusion in poultry diets can reduce inflammation and improve the overall health and performance of the birds.
- **Immune and Gut Health**: Curcumin supports immune function by enhancing macrophage activity and antibody production. According to a study by Kamaruddin et al. (2023), turmeric-supplemented broilers showed a significant improvement in gut health and immune response, especially in disease-challenged birds.
- **Growth and Feed Efficiency**: Turmeric has been shown to improve feed conversion and growth rates in broilers by enhancing nutrient digestion and absorption (Zhao et al., 2022).

8. Ginger (Zingiber officinale)

- **Digestive Stimulant**: Ginger is known for its ability to stimulate digestion by enhancing the secretion of digestive enzymes, improving nutrient absorption, and reducing gut irritation. This promotes better feed efficiency and growth rates in poultry.
- **Antimicrobial and Antioxidant Effects**: Ginger has antimicrobial properties that help control intestinal pathogens, and its antioxidant activity protects cells from oxidative stress. Research by Ahmad et al. (2021) highlighted ginger's effectiveness in improving gut health and growth performance in broilers under heat stress conditions.
- **Anti-inflammatory Benefits**: Ginger's anti-inflammatory properties help reduce inflammation in the gut, contributing to better nutrient absorption and overall bird health.

Mechanisms of Action of Herbs in Poultry

1. **Antimicrobial Action**: Many herbs, such as neem, tulsi, and kalmegh, contain bioactive compounds that act as natural antibiotics, inhibiting the growth of harmful bacteria in the gut. This reduces the reliance on synthetic antibiotics in poultry farming.
2. **Antioxidant Protection**: Herbs like amla, ashwagandha, and tulsi are rich in antioxidants that help protect cells from oxidative stress, which can damage tissues and impair immune function.

3. **Anti-inflammatory Effects**: Herbs such as turmeric and neem reduce inflammation in the gastrointestinal tract, which improves nutrient absorption and reduces the risk of digestive diseases.
4. **Immune System Modulation**: Herbs enhance both innate and adaptive immunity in poultry. Garlic, turmeric, tulsi, and neem are known to stimulate the production of immune cells and antibodies, helping poultry fight off infections and stress.

Benefits of Herbal Supplementation in Poultry

1. **Improved Growth Performance**: Herbs like tulsi, neem, and ashwagandha improve feed efficiency, nutrient absorption, and digestion, leading to better growth rates and weight gain in poultry.
2. **Enhanced Immune Function**: Herbs boost the immune response, helping poultry resist diseases more effectively. This is particularly important in antibiotic-free systems where disease prevention is crucial.
3. **Gut Health and Microbial Balance**: Herbal supplements promote a healthy gut microbiome by inhibiting harmful bacteria and supporting beneficial microbes, improving digestion and overall bird health.
4. **Reduction of Disease Incidence**: Herbal supplements can reduce the incidence of common poultry diseases like coccidiosis, bacterial infections, and parasitic infestations.

Challenges in the Use of Herbs in Poultry Production

1. **Variability in Herbal Composition**: The efficacy of herbs can vary based on growing conditions, plant species, and processing methods. This makes it difficult to standardize dosages and ensure consistent results.
2. **Optimal Dosage**: Determining the correct dosage for herbal supplements is challenging, as excessive doses can lead to toxicity, while insufficient amounts may not provide the desired effects.
3. **Cost and Availability**: While many herbs are readily available in Indian villages, their cost can be a limiting factor for some farmers. Ensuring the availability of high-quality herbs is also a challenge.
4. **Scientific Validation**: More research is needed to validate the efficacy of herbal supplements in large-scale commercial poultry production. While traditional knowledge is valuable, evidence-based studies are essential to establish standardized guidelines.

Conclusion

The use of herbs in poultry farming offers numerous benefits, including enhanced growth performance, improved immune function, and better gut health. In India, rural farmers have long relied on medicinal plants like tulsi, neem, and amla to maintain poultry health. As consumer demand for antibiotic-free and organic poultry increases, the use of herbal supplements is likely to play an increasingly important role in sustainable and natural poultry production systems. However, challenges related to standardization, dosage, and cost must be addressed to fully integrate these practices into modern commercial production.

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VALORIZATION OF COCOA POD HUSK IN AGROINDUSTRY AND COSMETICS

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ABSTRACT
Cocoa pod husk is a rich source of minerals (particularly potassium), fiber (including lignin, cellulose, hemicellulose and pectin) and antioxidants (e.g. phenolic acids). Among biomass raw materials, cocoa pod husk (CPH) which is the non-edible portion of cocoa (ca. 70–75% weight of the whole cocoa fruit) remain a promising bio-resource raw material for the production of high-value added chemicals but yet largely underexploited. Cacao pod husk product was used to extract dietary fiber and phenolic compounds. It is necessary to solve the problem of large quantities of organic waste, which represents an enormous ecological and financial burden for all aspects of the process industry. Studies have demonstrated that cocoa husk by-products can be utilized to produce valuable chemicals including ketones, carboxylic acids, aldehydes, furans, heterocyclic aromatics, alkylbenzenes, phenols, and benzenediols. Additionally, cocoa husk effectively removes lead from acidic solutions without being affected by other metals present in the solution. An economic assessment of converting cocoa pod husk into valuable chemicals and products is also addressed.

Keywords: Cocoa pod husk

Introduction

Cocoa (*Theobroma cacao L*) is an important economic crop in developing countries. Large quantities of underexploited by-products, such as cocoa pod husk (CPH) and pulp, are produced when cocoa beans are extracted from the pods. Cocoa pod husk (CPH) is the primary by-product, accounting for approximately 70-75% of the weight of the whole fruit during cocoa harvest, which is a significant and economically important crop in developing countries. The CPH consists primarily of fibrous materials including 19.7-26.1% cellulose, 8.7-12.8% hemicellulose, 14-28% lignin and 6.0-12.6 % pectin. The epicarp is enriched with lignin, while the mesocarp contains mainly (~50%) cellulose and the endocarp is rich in pectic substances. Gyedu, 2015 demonstrated with the amount measured as a percentage, w/w, dry weight cocoa pod husk is composed of protein (7-10), fat (1.5-2), carbohydrates (32-47), cellulose (19.7-26.1), hemicellulose (8.7-12.8), lignin (14-28), pectin (6.0-12.6), ash (6.4-8.4), minerals (K, Ca, Mg, P, Na and Fe) and phenolic content (4.6-6.9 g Gallic acid equivalent[1]/100g).

Cocoa pod husk use in agroindustry and environment

The use of biomass produced from cocoa pod husk is increasing as an alternative to non-renewable sources of energy and the properties of cocoa pod husk are potential adsorbents for undesirable compounds removal in industrial wastewater treatments. Potassium from cocoa husk can be a viable catalyst that generates high yields for biodiesel production and better engine performance (Ofori and Lee 2013). The cocoa pod husk generates a higher heating value (17Mj/kg) with high ash

content when crushed and carbonized at 400°C for 2 hours (Syamsiro *et al.,* 2012). Production of useful chemicals such as ketones, carboxylic acids, alkylbenzenes, aldehydes, phenols, furans, benzenediols, and heterocyclic aromatics through crosslinking enzymatic aggregate technology i.e., lipase immobilization (Mansur *et al.,* 2014). Efficient in removing lead from acidic solutions with maximum adsorption after 2 hours when adsorption tests were performed under agitation with different metallic elements and cocoa husk concentrations (Thiago *et al.,* 2022). Bello and Ahmad, 2011 stated that cocoa husk showed effective adsorption with adsorption of 111 mg/g of Remazol Brilliant (Black R) for its use as a dye-removing agent in textile industries when cocoa husk was activated with the reactive orange dye and subsequently carbonized at temperatures between 500-700°C.

Cocoa pod husk usage in cosmetics

Cocoa pod husk have a wide diversity of uses when related to human health, in which the husk can be used in the cosmetic field and prevention of diseases and as anti-microbial agents. A sun protection effect was observed by extracting cocoa husk with an ethanolic solvent (80%) to study the effect of skin lightening (Karim *et al.,* 2014). Compounds like resveratrol and fatty acids, such as linoleic acid, were isolated from an acetone-soluble extract of cocoa husk responsible for skin lightening properties and do not cause adverse effects (Parvez *et al.,* 2006) to make African Black soap, cocoa husk ash is used, along with *Cocos nucifera* (coconut oil), *Butyrospermum parkii* (raw shea butter) and others which are environmentally friendly cleansers and conditioners (Koiteh, 2013). Abdul *et al.,* 2016 stated the effectiveness of cocoa husk extracts in gel form reduced skin wrinkles and improved skin condition. From the results, it was observed that the extract is a potential ingredient for wrinkle reduction. In which the wrinkles of the skin reduced between 6 to 13%, between 3 and 5 weeks, still generating an increase in the hydration of the skin, around 3% after 3 weeks of application of the gel.

Conclusion

Due to its high nutritional value and the presence of valuable bioactive compounds, cocoa shells could potentially serve as a desirable raw material for a wide range of functional, pharmaceutical, or cosmetic products, as well as for energy production and biofuel. CPH contains a high amount of lignocellulosic content, pectin, potash, and phenolics. As an important economic crop in developing countries, the valorization of CPH and its fractions by developing end-user applications in the food and non-food sectors is regarded as beneficial for multiple stakeholders, industries, consumers, including farmers and academic researchers. Several fields of application, including human health, cosmetics, food industry and bioremediation have been suggested for the use of cocoa pod husk with very promising perspectives. The cocoa husk is a rich source of dietary fiber and protein, as well as valuable bioactive compounds (theobromine, caffeine, flavonoids, etc.). Due to its composition, it can be utilized as an ingredient in food processing or in other industries such as pharmaceuticals, cosmetics, or agriculture, with an endless increase in new applications. In addition, recovering cocoa husk has high economic value, as it is an inexpensive raw material for extracting various components and can be used as biofuel.

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APPLICATION OF BLOCKCHAIN TECHNOLOGY IN AGRICULTURE AND FOOD SUPPLY CHAIN

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Abstract
Agriculture is one of the most influential sectors in Indian Economy. Agricultural productivity is favorable to the economy, health and nutritional status of the country. In the modern era, agricultural scientists have adopted various technologies like IoT and Blockchain to realize higher farm yields. Blockchain, the revolutionary technology is used to address several problems of agriculture including supply chain management which provide accountability, protection, neutrality, and efficiency for all processes in the food supply chain.

Keywords: Indian Economy, IoT, Blockchain, Supply Chain Management

Introduction

The 21st century is all about technology. With the increasing need for modernization in our day-to-day lives, people are open to accepting new technologies. From using a remote for controlling devices to using voice notes for giving commands; modern technology has made space in our regular lives. Technologies like augmented reality and IoT that have gained pace in the past decade and now there's a new addition to the pack i.e. Blockchain Technology.

What is a Blockchain?

Blockchain can be described as a data structure that holds transactional records and while ensuring security, transparency, and decentralization. A Blockchain is a distributed ledger that is completely open to any and everyone on the network. Once information is stored on a Blockchain, it is extremely difficult to change or alter it and each transaction on a Blockchain is secured with a digital signature that proves its authenticity. Due to the use of encryption and digital signatures, the data stored on the Blockchain is tamper-proof and cannot be changed.

Blockchain technology allows all the network participants to reach an agreement, commonly known as consensus. All the data stored on a Blockchain is recorded digitally and has a common history which is available for all the network participants. This way, the chances of any fraudulent activity or duplication of transactions is eliminated without the need of a third-party.

Blockchain in Agriculture

Blockchain can be successfully applied to agricultural sector to increase food traceability. The use of Blockchain in agricultural sector ranges from having a sustainable business and reduction of waste, to informed consumer purchasing decisions, to having smooth future transactions with fraud elimination. Smart agriculture includes the utilization of natural resources and the decrease of environmental impact through the execution of ICTs, Blockchain and other modern technologies for gathering and analysing data.

From ICT to Blockchain

Information and Communication Technology does not avoid bias in the collection and use of data. Individuals operating ICT always are motivated to use data in a way that favors their own interest.

An effective way of avoiding such bias is to make data manipulation difficult or even impossible by distributing the power of data management to a very large number of individuals.

A Blockchain is a ledger in which agents take turns recording information on the process of generating, transacting and consuming a product or service. The ledger is collectively managed by all participating parties typically through a peer-to-peer network. A new record must be verified by the network before adding it to the Blockchain. Any alteration to the recorded data should follow consensus decision-making protocol, meaning the majority of the parties involved should agree. In addition, an alteration to one record will lead to the alteration of all its subsequent records. It is, therefore, almost impossible to change in data recorded in a Blockchain in practice. Blockchain is viewed as "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way".

The global Blockchain in agriculture and food supply chain market size is estimated at USD 302.8 million in 2023 and is projected to grow at a compound annual growth rate (CAGR) of 36.2 % by 2032. The continuous evolution and integration of technological advancements into Blockchain technology in the agriculture and food supply chain segment are expected to fuel market growth.

Use of Blockchain in Food Supply Chains

Food Supply Chain tracking is critical to explore the food's source. It ensures that the supplied eatables are safe to eat. But when it comes to how the food supply chain is managed currently, it becomes challenging for the food producers and retailers to confirm its origin. With the emergence of the Blockchain, it has become possible to bring trust and transparency in the food supply chain ecosystem, ensuring food safety for everyone.

Blockchain food supply chain can reduce food frauds with the help of the following steps:

Step 1: IoT sensors generating data or Farmers storing data.
Step 2: Distribution of grown crops to the food processing companies.
Step 3: Supply of Processed Food to Wholesalers and Retailers.
Step 4: Consumers can back trace the supply chain.

Use of Blockchain in controlling Weather Crisis

Farmers usually have to confront unpredictable weather conditions while growing different types of crops. Therefore, predicting and monitoring weather conditions are essential to crop survival. Many of the crops grown in the US cannot tolerate flooding due to excessive spring rains. The oxygen concentration level reaches zero, making it difficult for the plants to perform life-sustaining functions like water uptake, root growth and respiration. Moreover, the lack of transparency in the current food chain ecosystems can result in unclear and high surge pricing. Consumers are not aware of the crops suffered due to horrible weather conditions and that led to the increased costs. Due to Blockchain's ability to offer traceability and transparency, farmers and other stakeholders will be able to get a clear understanding of the price differences in the food distribution market. Since authorized parties can trace the weather conditions from the Blockchain ledger, farmers can quickly get the crop insurance claims through smart contracts.

Blockchain can help farmers in controlling weather crisis with the help of three steps:

Step 1: Agricultural Weather Stations sending essential information to the Blockchain.
Step 2: Farmers can take preventive actions.
Step 3: Quick application for the crop insurance.

Use of Blockchain in Managing Agricultural Finance

The lack of transparency, credit histories, and difficulties in contract enforcement are among the countless problems confronting formal financial inclusion and smallholders. The inability to access financial services can have an adverse impact on agricultural value chains' performance, which may lead to lower yield realization by the producers and inefficient supply of the commodities. Further, this results in buyers' difficulty to pay farmers on delivery, forcing poor smallholders to sell crops at the lower rates. In such situations, Blockchain brings fairness in the process of agricultural finance via transparency and shared control accessibility.

Blockchain can help in managing agriculture finance with the help of two simple steps:

Step 1: Stakeholders sharing information at every step of food production.
Every time a transaction will occur, it will be stored in the Blockchain, enabling all the involved parties to access every transaction transparently. Sharing essential information at every step of food production will bring more fairness to the entire system.

Step 2: Auditors can effectively conduct audits.
The Blockchain can also serve as a verification source for the recorded transactions, as it can store information permanently and securely. Instead of asking farmers or retailers to send financial reports for auditing purposes, the auditors will verify the transactions directly via Blockchain ledgers. The automated auditing process can make the audit environment cost-effective. Rather than carrying out assessments at the end of the year, audit firms will be in a position to conduct audits throughout the period. Blockchain will make it possible to replace the random auditing by auditors, making it more useful to access every single transaction.

Benefits of implementing the Blockchain in Agriculture

There are several benefits of implementing Blockchain technology in agriculture and are listed below:

1. Improved Quality Control and Food Safety

Blockchain can help us to bring increased transparency to the supply chain, remove ineffective processes and ensure optimal quality control conditions.

Crop failure is a prevalent issue faced by farmers around the globe. It usually happens because of unfavorable climatic conditions, such as poorly distributed rainfall and erratic weather. To solve this, many companies are investing millions into precision agriculture, creating IoT devices that allow farmers to monitor factors that could affect agriculture crops such as soil quality, pests and diseases and irrigation schedules.

By connecting these devices to a Blockchain ledger, the results can be updated continuously and viewed in real-time by just looking at an application on the phone. It will allow farmers to ensure that all factors are as they should be. If something goes wrong, they will be notified immediately to make adjustments before it is too late.

2. Increased Traceability in the Supply Chain

Consumer expectations for food standards are rising every day. Most notably, more and more consumers want to know where their food comes from. Using Blockchain technology will solve this problem by letting consumers know exactly where their food originated, who planted it, and how fresh it is. It will only require scanning the product at each stage in the process to update the database with information.

3. Increased Efficiency for Farmers

With the use of multiple apps developed by software development companies, farmers can record their data in spreadsheets and managing the farms efficiently. However, it isn't effortless and requires a lot of work to send this data to other service providers. Blockchain technology would allow farmers to store all of their data in one place to easily be accessed by those who need it, simplifying the entire process and saving valuable time and energy.

4. Fairer Payment for Farmers There are currently several problems that make it difficult for farmers to get paid for their produce, such as lower market price for the produce, delayed payment after sale and traditional payment mechanisms that often take a significant chunk of the farmers' profit.

Blockchain based smart contracts work by triggering payments automatically as soon as a specific, previously-specified condition has been fulfilled, and without charging excessive transaction fees. It means that farmers could receive payment for their goods as soon as they are delivered, without a significant portion of their income being taken away from them in the process. Many farmers also experience difficulty when they try to sell their products in the market at a fair price. Intermediaries enjoy most of the profits while doing a minimal amount of work in comparison. Smart contracts would eliminate the requirement of intermediaries, as it would allow farmers to connect directly with retailers. Therefore, they'd be able to receive a fairer price for their goods.

Conclusion

Blockchain technology has the prospect to solve many problems in the agricultural and food industry tremendously. Blockchain has enormous potential to significantly impact the way agricultural business is done. Further, the Blockchain technology can also increase trust between parties, facilitate information sharing throughout the supply chain and significantly reduce agricultural transaction costs.

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BAMBOO A SUSTAINABLE FIBERS FOR TEXTILES AND HANDICRAFTS

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Introduction

Cellulosic fiber derived from bamboo plants is called bamboo fiber. With exceptional biodegradable textile material and strength comparable to traditional glass fibers, it is a great potential green fiber.[1] Bamboos belong to the subfamily *Bambusoideae* of the grass family and are perennial blooming plants that are evergreen. The Dutch and Portuguese languages are where the word "bamboo" originated, most likely from Malay. Referred to as vegetable steel, bamboo is one of the most sustainable building materials available on the world. It can withstand earthquakes and has a tensile strength of 28,000 per square inch. After China, India has the second-highest genetic resource base for bamboo. Together, these two nations possess over half of the world's bamboo resources. India is said to be home to 125 native and 11 foreign species of bamboo, representing 23 genera. India is home to several major bamboo genera, including *Arundinaria, Bambusa, Chimonobambusa, Dendrocalamus, Dinochola*, and *Gigantochloa*.[2] Bamboo is a naturally occurring, renewable, biodegradable, and environmentally beneficial textile fiber. In addition to being environmentally benign, this fiber possesses intrinsic antimicrobial and UV protection qualities, making it a special kind of eco-friendly textile material for the twenty-first century. Due to its high tensile strength, stability, and durability, it is not only utilized in conventional textiles but is also a highly valuable composite material for high performance end applications. Bamboo is a type of fiber similar to ramie, flax, and jute. The main plant parts of bamboo are leaves, flowers, culms, branches, rhizomes, and roots. Bamboo fiber is used in a variety of textile applications and products. Because of its unique qualities, bamboo fiber is widely used in the textile industry. It may be found in a variety of textile forms, such as yarns and woven and knitted fabrics.[2] Massive woody plants called bamboo have historically been utilized for building, furniture, fences, and social and economic purposes.[3]

Why bamboo?

- Sustainability - as it grows very fast
- Short rotation- the bamboo tree can be harvested from 3ears onwards.
- Adaptability- different agro climatic conditions
- Economical- Easily available at cheaper price.
- Environmental friendly-Carbon sequestration, land reclamation, water harvesting, reduce soil degradation etc.
- Plantation- large scale plantations can be brought up easily.

- Uses- more than 1500 documented uses.
- Social acceptance-like by the society from old costumed baskets to furnished bamboo flooring.

Processing of Bamboo for natural fibers

Bamboo fibre can be obtained through various methods, such as retting, mechanical extraction and chemical extraction. The characteristic exhibited by bamboo products largely depend on whether the bamboo fibre is derived from natural sources or is a regenerated type. The first two methods yield bundles of original or pure bamboo fibres in staple form, while the latter produces bamboo viscose filaments, also known as regenerated bamboo cellulose, which can be further transformed into staple fibres if necessary. In order to extract fibres from the bamboo Culm, all three processes begin by splitting bamboo strips directly taken from the Culm to eliminate the diaphragm and node[2]. Depending upon the type of fabric bamboo fibre can be produce two different chemical methods. Majority of the bamboo fibres are produced by viscose rayon processing method. Which is cheap to produce but it has some environmental downside. Actually this method is regenerated or semi synthetic fibre processing method.[3]

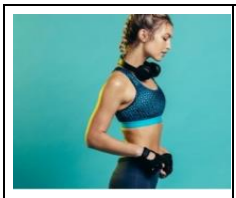
Application of Bamboo

1. Textiles - Apparels and technical textiles
2. Handicrafts - Housing and utility products



Uses of Bamboo Fibres in Textile World

Bamboo fabric may be used in sheets, blankets, towels, hand towels, or a number of other household textiles. Due to its softness and durability, however, this fabric is most commonly used in garments, intimate apparel uses, sanitary purpose & medical uses, UV resistant product, household uses etc.

					
Sportswear	**Shocks**	**sanitary pad**	**T- Shirts**	**Sanitary pad**	**Towels**

Advantages of Bamboo Fibre

- Green and eco-friendly.
- Soft and drapeable and natural anti-bacterial property.
- UV protection property and sweat absorbant
- Smooth & luxurious to the touch.
- Good breathability, cool and comfortable to wear.
- Anti-static, strong and durable.
- Abrasion Resistant



Uses of bamboo in technical textiles

It was highly interested in the manufacture of composites and panels made of bamboo, which were inspired by the developments in the woodworking industry. Together with great wear resistance,

appropriate stiffness, and minimal distortion, the bamboo composites show excellent proportions, dimensional stability, and a constant size. Other benefits of bamboo composite goods include excellent impact resistance, low maintenance, weather resistance, and so on.A type of composite material made by combining bamboo fibers and a thermoplastic polymer is called bamboo fiber reinforced thermoplastic polymer composite. The strength, stiffness, and durability of the composite material are increased by the reinforcement provided by bamboo fibers. Engineered bamboo is specified and governed by the ASTM International Standards. It is available in several forms, such as laminated bamboo and bamboo scrimber, which has three times the structural capacity of regular timber.

Traditional uses of bamboo

- The bamboo are used for pulp, paper and rayon (major industrial uses)
- It is used in agriculture and handicrafts products like bamboo basket, stacking materials, agriculture implements and structural buildings.
- Sericulture, Fisheries, medicinal
- Bamboo seeds and shoots used as food and leaf as fodder
- Panels as substitute of traditional timber spp, plywood particle board, hard board, medium density fibers board.
- Other importance uses of bamboo are carbon sequestration, checking soil erosion water conservation wind barrier, bio fencing restoration of degraded land, important social forestry and agro forestry species.






Modern used of bamboo

For roofing: The roof offers protections against extremes of weather including rain, sun and wind and to provide shelter, clear and usable space beneath the canopy. Above all it must be strong enough to resist the considerable forces generated by wind and roof coverings.




Scaffolding: Because of the favourable relationship between load bearing capacity and weight, bamboo can be used for the construction of save scaffolding even for very tall buildings. Only lashed joints are used. The cane extension is carried out by lashing the cane ends together with several ties.

Bamboo Handicraft

The important crafts of Meghalaya include weaving, wood-carving, cane and bamboo work, carpets, fishing equipments, utility items, storage items and making of musical instruments. Both involve weaving patterns and material mostly used is of bamboo. Bamboo working is the activity or skill of making items from bamboo, and includes




architecture, carpentry, furniture and cabinetry, carving, joinery, and weaving. Its historical roots in Asia span cultures, civilizations, and millennia, and are found across East, South, and Southeast Asia. Bamboo crafts permeate all aspects of our life. Bamboo is used for house construction, for fishing and farming implements, for musical instruments and much more. Bamboo items may still be found in the handicraft section of most public markets. The poles can be used as containers for water or for gathering wine.

Potential areas of increased demand of bamboo

The scarcity of forest wood has led to a high demand for bamboo. Bamboo is utilized in the creation of contemporary furniture, textiles, bridges, airports, and hotels, in addition to bamboo plywood and lumber. Value-added goods, bio-char, bamboo plastic composites, plywood, particle board, medium density fiber board, bamboo mat, bamboo cement panel, bamboo homes, including earthquake-resistant homes, and structural and building materials, among other things. Due of bamboo's versatility and wide range of applications, these projects can be in the building, furniture, food, cosmetics, arts and crafts, or other industries. A socioeconomic component that includes gender equality, food security, and income improvements is one of the specific objective outcomes and impacts. The category of traditional products includes handicrafts. Almost 19% of all bamboo cultivated in India is used to make handicrafts. As a substitute for wood, its highly valued use not only fosters economic growth but also conserves forest resources, safeguarding our natural environment. Bamboo fiber's aesthetic qualities, fineness, flexibility, innate antibacterial activity, and UV resistance have already helped it become increasingly popular in the textile industry. Furthermore, it is a green textile material that is eco-friendly, the sustainable textile solution of the twenty-first century.

Conclusion

Regenerated cellulosic fiber made from bamboo is called bamboo fiber. Bamboo stems and leaves are processed into starchy pulp by alkaline hydrolysis and multi-phase bleaching. Many individuals are adopting bamboo as a “green” material. It grows swiftly and is a natural fiber. In an effort to reduce the potential harm to ecosystems and provide fairly priced polymeric reinforced composites, researchers are working to create composites made entirely of natural, biodegradable fibers. Thus, there has been a discernible increase in the application of bamboo fibers. Bamboo fabric can be utilized for various household textiles such as sheets, blankets, towels, and hand towels. But clothes are the main application for this fabric because of its softness and longevity. It is one of the most comfortable textiles because it is not only softer than silk but also antibacterial, wrinkle-resistant, and, when produced responsibly, environmentally beneficial. Because of its distinctive qualities and sustainability, bamboo apparel is becoming more and more popular. Compared to chemically

regenerated bamboo fiber, mechanical extraction of bamboo fiber is becoming a more environmentally benign method.

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