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ENHANCING FARMERS' INCOME THROUGH RICE-FISH FARMING

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Abstract
Rice-fish farming integrates rice cultivation with fish farming in the same field, offering a sustainable solution to enhance farmers' income and food security while mitigating environmental impacts. This integrated system improves economic stability through diversified revenue streams, provides nutrient-rich food, and reduces reliance on chemical inputs. Challenges include water management, technological gaps, and labor requirements, which require targeted research, training, and policy support. Future advancements should focus on optimizing water use, enhancing crop and fish varieties, and strengthening market linkages. By adopting synergies between agriculture and aquaculture, rice-fish farming holds promise for achieving sustainable development goals and ensuring resilient livelihoods in the face of climate change.

Keywords: rice-fish farming, integrated farming, sustainable agriculture, food security

Introduction

The Food and Agricultural Organization (FAO) has set ambitious goals for 2030, including eradicating poverty and hunger while promoting sustainable consumption and production. The global human population has projected to reach 9.7 billion by 2050 (United Nations, 2019). Addressing severe food insecurity affecting 750 million people worldwide requires a 70% increase in food production by 2050 (ELD, 2015). However, expanding agricultural land is limited by urbanization, land degradation, and climate change impacts. Rice production must exceed 1,035 million tons by 2050 through enhanced productivity and diversification. Yet, the extensive use of chemical fertilizers and pesticides has led to environmental issues such as soil and water pollution and greenhouse gas emissions from paddy fields. Similarly, India's aquaculture, despite being the second-largest fish producer globally, faces challenges like high feed costs, disease outbreaks, and significant environmental impacts, including biodiversity loss and greenhouse gas emissions. Therefore, rice-fish farming emerges as a sustainable solution, combining rice cultivation and aquaculture on the same land. This traditional practice in parts of northeastern India and Kerala has been strengthened by recent research advancements. Integrated rice-fish farming enhances food production, improves the economic stability of vulnerable farmers, and reduces environmental damage. This system leverages efficient water use, offers nutritious food, and

minimizes negative impacts like eutrophication and methane emissions from intensive aquaculture. This article mainly focuses on the concept, components, advantages, constraints, and future needs of rice-fish farming, emphasizing its potential to boost farmers' income.

Concept of rice fish farming

Rice-Fish farming system constitutes a unique agro-landscape system across the world especially in tropical and sub-tropical Asia. Rice-fish farming involves the simultaneous or sequential cultivation of rice and fish in the same field. This system influences the symbiotic relationships between rice and fish, where rice provides a habitat for fish, and fish contribute to the ecosystem by regulating microclimatic conditions, controlling pests by feeding on larvae, enhancing soil fertility, and improving water quality. There are two primary types of rice-fish farming: concurrent and rotational systems. In the concurrent system, rice and fish are cultivated together, while in the rotational system, rice and fish are grown in the same field but at different times of the year.

Fig 1. Rice-Fish Farming System (*Image Credit: Rice-Fish Farming, Flickr.*)

Components of Rice-Fish Farming System

- **Crop Husbandry:** In the rice-fish farming system, selecting appropriate rice varieties is crucial for optimal yield and compatibility with fish culture. Suitable rice varieties include Jaladhi-1, Jalmagna, Jaladhi-2, Manika, Utkal Prabha, Mahalaxmi, FR-13A, Jal Lahri, Panidhan, Jal Nidhi, and Jal Priya. These varieties are known for their vigorous growth in hypoxic (oxygen-deficient) conditions, which helps alleviate issues related to poor seedling establishment and provides a weed-suppressing advantage during early flooding. To supplement nitrogen requirements, Azolla (*Azolla microphylla*) can be grown alongside paddy. Azolla is inoculated into the rice field at a rate of 500g/m² nine days after transplanting, contributing significantly to the nitrogen content in the soil.
- **Pisciculture:** The selection of fish species that thrive in shallow water, tolerate high turbidity, and exhibit rapid growth is essential for successful rice-fish culture. Suitable species include Catla (*Catla catla*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*),

Common Carp (*Cyprinus carpio*), and exotic species such as Grass Carp (*Ctenopharyngodon idella*) (Bhattacharyya *et al*., 2013; Poonam *et al.*, 2019). These fish species have specific feeding habits, with Catla feeding at the surface, Rohu in the water column, and Mrigal at the bottom layer of the pond ecosystem.

The recommended stocking density is 7,500 fingerlings per hectare of ponded water. The fish species are maintained in a ratio of 1:2:3:4, with Grass Carp (grass and algal feeder), Rohu (column feeder), Mrigal/Common Carp (bottom feeder), and Silver Carp/Catla (surface feeder) respectively. To ensure optimal growth conditions, the pH of the pond water should be maintained around neutrality, which can be achieved by adding lime at regular intervals.

Site Selection and Field Preparation for Rice-Fish Farming

The success of rice-fish farming system hinges on careful site selection and meticulous field preparation to ensure optimal conditions for both rice cultivation and aquaculture. An annual rainfall of approximately 80 cm is ideal, providing adequate flooding necessary for rice and fish. The topography should be relatively flat or gently sloping with a uniform contour and high water-retaining capacity, facilitating efficient water management and retention. Continuous water availability is crucial; thus, low-lying areas with easy water flow and year-round access to natural sources like rivers, streams, or groundwater are preferred. Soil fertility is another critical factor, with fertile soils rich in organic matter and medium texture, such as loam or silty clay, being ideal due to their excellent nutrient balance and drainage properties. The preparation of the rice field is influenced by the topography and contours of the land. Three types of rice fields are commonly identified for integrated rice-fish farming (Diarte-Plata & Escamilla-Montes, 2019):

a) **Perimeter-type Field:** In a perimeter-type field, the land is prepared with a moderate elevation, with the ground sloping towards perimeter trenches. These trenches facilitate easy drainage and water management. The central area of the field is used for rice cultivation, while the perimeter trenches provide a habitat for fish. This design allows for efficient use of space and resources, as the fish can move freely around the perimeter while the rice grows in the center.
b) **Central Pond-type Field:** A central pond-type field features a pond created in the middle of the rice field. This design provides a straightforward method for integrating aquaculture with rice production. The central pond serves as the main habitat for the fish, while the surrounding rice fields benefit from the nutrients provided by the fish. This layout simplifies the management of water levels and facilitates the movement of fish and nutrients between the pond and the rice fields.
c) **Lateral Trench-type Field:** Lateral trench-type fields have trenches prepared on one or both sides of the rice slopes. These trenches allow for efficient water management and integration of aquaculture. The lateral trenches provide a habitat for the fish, while the rice grows on the elevated slopes. This design ensures that the fish have access to the nutrients in the water while maintaining optimal conditions for rice growth.

Advantages of Rice-Fish Farming

1. Enhanced Income and Economic Stability: Rice-fish farming significantly increases farmers' income by providing an additional source of revenue from fish sales. Studies have shown that integrated farming can increase net profits compared to rice monoculture. For instance, the net profit from rice-fish farming can be three times higher than from rice monoculture.

2. Improved Nutritional Security: The integration of fish into rice fields provides farming households with a balanced diet, combining carbohydrates from rice with high-quality protein, vitamins, and omega-3 fatty acids from fish. This dual production system takes into consideration food and nutritional security significantly contributing to better health outcomes.

3. Environmental Benefits: Rice-fish farming promotes ecological sustainability by reducing the need for chemical fertilizers and pesticides. Fish help control pests and weeds naturally, leading to a healthier ecosystem. This system also supports nutrient cycling, improves soil fertility, and reduces greenhouse gas emissions, particularly methane.

4. Increased Productivity: The movement and feeding behavior of fish in rice fields improve dissolved oxygen levels, enhance soil fertility, and control pests and weeds. These interactions result in increased rice yields, often by 7-30%. Additionally, fish farming in rice fields can produce substantial quantities of fish, contributing to overall food productivity.

Constraints of adopting Rice-Fish Farming

1. Water Management: Effective water management is crucial for the success of rice-fish farming. Challenges such as water scarcity, drought, inadequate irrigation facilities, and the risk of fish escape due to flooding can hinder the adoption of this system. Efficient water use practices, such as rainwater harvesting and irrigation management, are essential to address these issues.

2. **Damage to rice seedlings:** fishes may significantly destroy young rice seedlings either by uprooting (carps) or feeding on them (*Tilapia rendalli*).

3. Technological and Extension Gaps: Many farmers lack the technical knowledge and skills required for integrated rice-fish farming. Agricultural extension services often do not have the expertise to advise on both rice and fish cultivation, leading to inadequate support to farmers. Coordination between agricultural and fishery extension services is necessary to promote the adoption of this system.

4. Use of Agrochemicals: The excessive use of chemical fertilizers, pesticides, and herbicides in intensive rice cultivation poses a significant threat to fish health. These chemicals can contaminate water bodies, making it difficult to maintain a healthy fish population. Organic farming practices and integrated pest management (IPM) strategies should be encouraged to mitigate this issue.

5. Labor and Risk: Integrated rice-fish farming can be labor-intensive and requires careful management to balance the needs of both rice and fish. The initial investment and risk associated with adopting new farming practices can deter resource-poor farmers from implementing this system. Providing training and financial support can help alleviate these challenges.

Future Needs for advancement in Rice-Fish Farming

a) **Research and Development:** Continued research is needed to develop and refine rice-fish farming practices, particularly in the context of climate change. Studies should focus on optimizing water management, selecting suitable rice and fish varieties, and improving disease management. Collaboration between researchers, policymakers, and farmers is essential to address these challenges.
b) **Training and Capacity Building:** Training programs should be conducted to educate farmers on the benefits and techniques of rice-fish farming. Extension services must be strengthened

to provide technical support and promote the adoption of this system. Building farmers' capacity to implement integrated farming practices will enhance their ability to manage risks and increase productivity.

c) **Policy Support and Incentives:** Governments should develop policies and provide incentives to encourage the adoption of rice-fish farming. Subsidies for inputs, access to credit, and financial incentives for sustainable farming practices can motivate farmers to transition to integrated systems. Policies should also focus on ensuring the availability of high-quality inputs and promoting organic farming practices.

d) **Infrastructure Development:** Investment in infrastructure, such as irrigation facilities, storage, and transportation, is critical to support rice-fish farming. Building higher dikes with fencing and netting around rice fields can prevent fish escape during floods. Improved infrastructure will enable farmers to manage water resources effectively and reduce losses.

e) **Market Access:** Creating market linkages for fish and rice products is essential to ensure that farmers can sell their produce at fair prices. Developing value chains, promoting local markets, and facilitating access to regional and international markets will enhance farmers' income and economic stability.

Conclusion

Rice-fish farming presents a promising opportunity to boost farmers' income, enhance food security, and promote environmental sustainability. By leveraging the synergies between rice and fish, this integrated farming system can provide substantial economic and nutritional benefits. Despite the challenges associated with water management, technological gaps, and labour requirements, the future of rice-fish farming looks promising with appropriate research, training, policy support, and infrastructure development. Adopting rice-fish farming can contribute to a blue-green revolution, ensuring a sustainable and prosperous future for farming communities.

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ARECANUT BASED CROPPING SYSTEM: A BOON FOR SMALL FARMERS

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Abstract
Arecanut is a highly profitable plantation crop; its cultivation integrates well with other crops. The cropping system helps to enhance the soil health by improving its properties through the continuous addition and recycling of organic matter to the soil and allowing farmers to diversify their income sources and reduce the risk of losses associated with monoculture. In India, Arecanut based cropping system represents the advantages, disadvantages and consequences of adopting cropping system on productivity, soil fertility, profitability and proper resource use. This system also serves as a sustainable and profitable option for small farmers, offering a pathway to improve the livelihood and agricultural resilience.

Key words : Arecanut, Soil, Farmer, Resources, Productivity

Introduction

Arecanut (*Areca catechu* L.) is important plantation crop belongs to family Arecaceae, which is having leading production in India grown in humid subtropical regions of Karnataka (40 %), Kerala (25 %), Assam (20 %), West Bengal, Tamil Nadu and Meghalaya. It is popularly known as Supari and Betelnut, which are chewed with betel leaves as a stimulant. It is growing for chewing nut, mainly used for masticatory purposes in many parts of South East Asia and parts of the palm are useful in making hard boards, plates and brown wrapping paper.

Arecanut in Diversified Cropping System

Arecanut is having long pre-bearing period *i.e* about 5-6 years of planting and it is expected to generate economic yield over a span of 40 to 50 years. During initial period of crop, there will be low or no income which gives scope for raising mixed or intercrops between the spaces of arecanut garden. The effectiveness of arecanut based cropping system (ABCS) depends on the relative shade tolerance of component crops. Growing of sole crop does not utilize the natural resource fully such as soil, water, space and light.

Spacing: It is perennial crop which is generally having spacing of 2.7 m X 2.7 m. Rooting pattern of arecanut palm showed that it could use only 30 % of the land area with spacing and cultural operations are restricted in the radius of 75 cm from base of the palm due to 61 % of all the major roots and 51 % of fine roots are located within the radius of 50 cm from the trunk of the palm. Thus, the each arecanut palm utilize only 2.27 m^2 (40 % of land area) of land out of 7.29 m^2 area offered to each palm.

Light: plant is having compact nature of crown raised well at a distance of 10 to 15 m above the ground which allows transmission of more sunlight to ground and helps to maintain high humidity, favours excellent growth of shade loving intercrops/mixed crops. Arecanut intercepts only 43 % of the incident light, but this can be boosted to 95 % by cultivating mixed crops within the arecanut garden. In mixed cropping systems, sometimes light becomes limiting factor for growth due to reduced penetration of light to ground level because of more interception and absorption of light by the taller canopy. In this situation shade-tolerant species thrives better in low light intensity and shows superior performance

How ABCS is boon to farmers?

Arecanut essentially serves as a crop for small and marginal farmers who is having less than one hectare land, hold struggle with insufficient income to support their families. Some of the main problems in arecanut farming are the long pre-bearing time, price fluctuations in market, unexpected loss from environmental condition, pest and disease incidence, etc. Hence farmers are advised to take a multispecies cropping system in their arecanut gardens in order to address these issues to get additional income. Integrated farming systems allow intensification of production and helps to increase income, reduce soil degradation and improves soil health and benefit poor farmers.

Suitable crops for multiple cropping

Spices: Black Pepper, Bay Leaf, Ginger, Turmeric, Cardamom, Nutmeg, Vanilla, Cinnamon, Clove, Betelvine

Fruit crops: Pineapple, Acid lime and lemon

Plantation crops: Cocoa, Coffee

Medicinal and aromatic plants: Long Pepper, Shatavari, Davana, Patchouli

Vegetable crops: Elephant Foot Yam, Arrow root, Colacasia, Basella and Radish

Flower crops: Heliconia, Marigold, Aster, Anthurium and Chrysanthemum

Implications of cropping systems on soil fertility

The purpose of cropping system is not only to get additional yield and income but also to improve the soil health and fertility status in the long run. Cultivation of intercrops with main crops which add organic matter in the form of leaf and shoot debris continuously into soil. Recycling of these organic matter helps to maintain soil fertility by improving wealth of beneficial soil micro-organisms and enzyme. Studies revealed that soil micro-flora and fauna are varied with status of soil, cultivation practices and cropping pattern and their presence is associated with the perennial crops are most likely to be constant in their quantitative nature and abundance. Beneficial micro-organisms such as bacteria, fungi, actinomycetes, N_2-fixers and P-solubilizers are more in high density multiple cropping compared to arecanut monocropping. In situ addition of organic matter through recycling of organic wastes and dead and decayed leaves and roots are resulted in increase of organic carbon in the system. Major soil nutrients like nitrogen, phosphorous and potassium content is high in surface soil than subsurface due to abundance of organic matter in top layer of soil.

Benefits of arecanut based cropping system

- Effective utilization natural resources such as soil, water and space
- Efficiency in usage of water by plants

- Reduction of soil degradation and soil erosion
- Enriching soil health by improving soil fertility
- Well utilization of photosynthetically active radiation
- Additional income from mixed/intercrops with main crop

Constraints in arecanut based cropping system

- All the crops are not suitable to grow under multiple cropping system *i.e* shade tolerant species are can be well grown.
- Lack of technical knowledge about management of system
- Non availability of skilled labour and good quality planting materials
- Lack of funds and inputs for establishment of cropping system
- Incidence of pest and disease from one species to other

Management of cropping systems

Arecanut based cropping system get success mainly with proper choice of intercrops with varied canopy and height, planting geometry, different species have to be selected to avoid incidence of pest and diseases. They are planted in between the space of arecanut with their recommended spacing. Fertilizer recommendations for cropping systems have generally depend on each fertilizer schedules for each crop to avoid nutrient competition between crops. In cropping system, the amount of water needed for growth of plants does not increase, but transpiration losses could rise due to mixed cropping. However, crop cover and the presence of crop residues holds high soil moisture and water use efficiency are expected to lower evaporation and runoff losses. To determine irrigation needs for the crop is based on moisture depletion for the primary/base crop in cropping system. There is very less growth of weeds due crop residues which generated can be used as mulch. This helps to reduce growth of weeds and conserve soil moisture.

Conclusion

On the basis of constraints and challenges faced by arecanut growers, there is need for intrusion from government to strengthen training labour for skill development, production and supply of planting materials in large quantities, providing subsidies and minimum support price for crop protection measures for small and marginal farmers *etc*., will encourage them to adopt multispecies cropping system. Undoubtedly, arecanut based cropping system generates supplementary income but also serves as a safeguard against price fluctuation in the main crop. It has potential of employment generation for improving rural livelihoods. Proper selection of crops and their quality planting materials is essential for a successful cropping system. Farmers will be encouraged to follow cropping system by a ready and secure market. Before implementing system, arecanut growers should understand the scientific basis for its management and other practices. There is a strong conviction that arecanut based cropping system is essential for ensuring profitability and sustainability in farming practices.

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ADVANCEMENT IN GENOME EDITING TECHNIQUES FOR DISEASE RESISTANCE IN PLANTS

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Abstract
Diseases severely reduce crop yield and quality by 20-40% (FAO, http://www.fao.org/news/story/en/item/280489/icode/), there by threatening global food security. Genetic improvement of plant disease resistance is essential for sustainable agriculture. Genome editing has been revolutionizing plant biology and biotechnology by enabling precise, targeted genome modifications. Editing provides new methods for genetic improvement of plant disease resistance and accelerates resistance breeding. Although traditional breeding continues to play a vital role in crop improvement, it typically involves long and laborious artificial planting over multiple generations .To date, a number of disease resistance crops have been produced using gene editing tools, which can make a significant contribution to overcoming diseases-related problems. Recently, the application of innovative genome engineering techniques, particularly CRISPR-Cas9-based systems, has opened up new avenues that offer the prospects of sustainable farming in the modern agriculture industry.

Keywords : genetic improvement, gene editing, disease resistance, genome modifications, traditional breeding, CRISPR-Cas9

Introduction

Diseases are major and important constraints that threaten agricultural development and global food security. At present, the main strategies for controlling crop diseases remain highly dependent on chemical pesticides (Damalas CA. Since pesticides are generally not highly specific, they can also influence other organisms while killing pathogens, thereby disturbing ecological balance. To meet these needs, different techniques have been developed to produce new cultivars with novel heritable mutations. Although conventional breeding continues to play a vital role in crop improvement, it typically involves long and laborious artificial planting over multiple generations. Compared with conventional breeding, genetic engineering, which entails the use of biotechnology for direct editing of the genetic materials of organisms has numerous benefits.

First, it can facilitate the insertion, deletion, modification, disruption, or fine tuning of particular genes of interest and causes minimal, if any, undesirable alternations in the remaining crop genome. Moreover, crops with desired traits can be obtained within fewer generations. Second, genetic engineering requires the exchange of genetic materials between species. Consequently, the initial genetic material that can be used in this phase is not restricted to a single organism. Third, in the process of genetic modification, plant transformation can introduce new genes into vegetatively propagated crops including cassava (*Manihot esculent),* potato *(Solanum tuberosum),* and banana *(Musa spp*. Fourth, genetic crosses and segregant progeny selection are generally labour-intensive and time consuming.

Therefore, it is a challenging for conventional breeding to keep pace with continually changing pathogens and increasing food demand, particularly during an era of global climate change (Gao C.2018). These challenges to our current agricultural practices suggest the need for new technologies. For example, new technologies such as transgenesis have shown to important in overcoming such challenges and securing world food security.

Genome editing technology:

Genome editing is a process where an organism's genetic code is changed. The different editing tools act on a similar basic principle: the enzyme is directed to a specific target site in the genome by either a guide sequence or by specific DNA binding domains within the nuclease itself. Double Stranded Breaks (DSBs) are repaired mainly via two pathways: the non homologous end joining (NHEJ) pathway and the homologous recombination (HR) pathway. In most cases, cells use the NHEJ pathway to repair DSBs (Voytas DF and Gao C 2014). However, NHEJ is error prone and usually results in insertion or deletion mutations. In the presence of a donor DNA template, DSBs are likely to be repaired by the HR pathway, which results in precise base changes or gene replacement. There are several types of gene editing tools which help in resistant to diseases in plants. Restriction enzymes, Zinc Finger Nuclease, TALENs , CRISPR cas9, Prime editing.

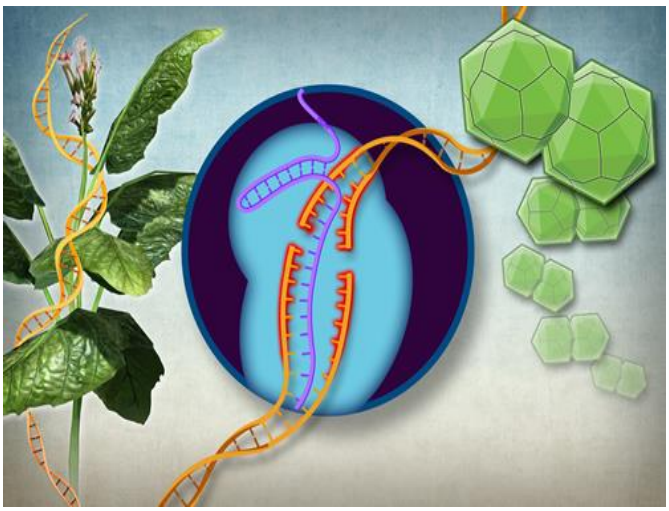

Figure 1: Gene editing technology (Source: Ali Z *et al.* 2004)

Restriction Enzymes: the original genome editors

A restriction enzyme is a protein isolated from bacteria that hydrolyze DNA at specific sequence (Arber and Linn,1969) producing DNA fragments with a known sequence at each end. The use of restriction enzymes is critical to certain laboratory methods, including recombinant DNA technology and genetic engineering.

Restriction enzymes are not commonly used for gene editing these days, since they are limited by nucleotide patterns they recognize, but they remain widely used today for molecular cloning. Additionally, certain classes of restriction enzymes play key roles in DNA mapping, epigenome mapping, and constructing DNA libraries.

Zinc finger nucleases: increased recognition potential

As time went on, the need for precision in genome editing became more evident. Scientists needed a gene editing technique that recognized the site they wanted to edit, as off target –

effects could be deleterious. The discovery of Zinc Finger Nucleases (ZFN) in the 1980s addressed this issue.

ZFNs are composed of two parts: an engineered endonuclease Fok1(Kim *et al*. 1996**)** fused to zinc finger DNA-binding domain recognizes a 3-base pair site on DNA and can be combined to recognise longer sequences (Smith *et al*. 2000**)**. Additionally, the ZFNs function as dimmers, increasing the length of the DNA recognition site and consequently increasing specificity. However, while specificity increased with ZFNs , it was not perfect.

Transcription activator-like effector nucleases: single nucleotide resolution

In 2011, a new gene editing technique emerged, which was an improvement over ZFNs. TALENs are structurally similar to ZFNs. TALENs can be readily delivered into cells as mRNA (Mahiny *et al*. 2015; Mock et al. 2015**)** and even protein **(**Cai et al. 2104; Liu *et al*. 2104a). Both methods use the Fok1 nuclease to cut DNA and require dimerization to function, however, the DNA binding domains differ. TALENs use transcriptor activator like effectors (TALENs), tandem arrays of 33-35 amino acid repeats. Further TALENs displayed decreased editing efficiency in heavily methylated regions. TALENs have been used in the field of medicine as well as agriculture.

CRISPR-Cas9 gene editing: genome editing revolutionized

In the year 2012, scientist discovered a new method of genome editing derived from CRISPR-Cas9, a system that has long existed in bacteria to help them fight off invading viruses. CRISPR is an elegant two component system consisting of a guide RNA and a Cas9 nuclease. The Cas9 nuclease cuts the DNA with the 20 nucleotide region defined by the guide RNA. With CRISPR, scientists can customized their guide RNAs, and algorithms have been developed to assess the chances of off target effects.

CRISPR has completely revolutionized what genome editing can mean for our future by increasing the speed and breadth of science. The advancement in genome editing techniques have opened up new doors for what genome editing can do to address issues in medicines, agriculture and beyond.

Prime editing: editing without double- stranded breaks

Prime editing systems allow for all possible transition mutations, as well as small insertions of up to 50 nucleotides and deletions up to 80 nucleotides. This system works using a Cas9 nickase, which induces single stranded breaks in DNA, fused to a reverse transcriptase enzyme. Rather than using an segment and a donor template for repair, prime editing uses a single engineered construct as a prime guide RNA (peg RNA), which is made up of prime binding site (PSB) sequence and a sequence containing the desired edit. After it finds the target, the Cas9 nickase creates a cut in one strand of the DNA and the reverse transcriptase uses the pegRNA as a template for reverse transcription, attaching the corresponding nucleotides to the nicked DNA end.

Editing Plants for Disease Resistance:

Several traditional methods have been successfully developed for breeding disease resistance. The pure line method, specifically developed for self-pollinated crops, was used to breed the Kanred variety of wheat, which is resistant to rust (Allen RF. 1921). The pedigree method has been widely used for developing disease-resistant varieties controlled by major genes. The backcross method and recurrent selection have been developed for improving elite varieties resistance to rice blast.

Interspecific hybrids have been used to generate resistance to cotton rust by transferring resistance genes from *Gossypium anomalum* and *Gossypium arboreum* into *Gossypium hirsutum*. The mutation breeding method has been successfully used to produce many lines resistant to rice blast. However, traditional methods for breeding resistance are time-consuming, and the resistance alleles are sometimes linked to genes that influence plant development.

Plant pathogens pose a major threat to crop productivity. Typically, phytopathogens exploit plants' susceptibility (S) genes to facilitate their proliferation. Disrupting these S genes may interfere with the compatibility between the host and the pathogens and consequently provide broad-spectrum and durable disease resistance. In the past, genetic manipulation of such S genes has been shown to confer disease resistance in various economically important crops. Recent studies have accomplished this task in a transgene-free system using new genome editing tools, including clustered regularly interspaced palindromic repeats (CRISPR). In this Opinion article, we focus on the use of genome editing to target S genes for the development of transgene-free and durable disease-resistant crop varieties.

Figure 2: Genetically modified plants (Source: Klumper W *et al*., 2014)

Resistance against Bacterial Pathogens:

Rice bacterial blight, a rice vascular bundle disease caused by *Xanthomonas oryzae* pv. *oryzae* (*Xoo*), has high epidemic potential and is one of the major diseases of rice. It causes 10–20% losses of yield, but this loss can surpass 50% under conditions favourable to the pathogen (i.e. high humidity) and can sometimes even result in complete loss of yield (Ou SH.1985). *Xoo* secretes TALE (transcription activator-like effector) proteins into host cells through the type III secretion system. Many TALE proteins target S genes and activate their expression to promote successful infection]. For example, the TALE protein AvrXa7 from the Philippine strain PXO86 binds to the effector-binding element (EBE) in the promoter of *OsSWEET14* (also called *Os11N3*) and activates its expression.

Resistance against Fungal Pathogens:

The discovery of barley *mlo* (*mildew resistance locus o*) mutants is a major success in plant breeding for broad-spectrum and durable resistance to powdery mildew (Lyngkjaer M et al. 2000). Mlo resistance has been widely used in spring barley throughout Europe for nearly 40 years. After

cloning the barley *Mlo* gene in 1997, *Mlo* orthologues were found to be evolutionarily conserved in dicots and monocots. Since bread wheat is an allohexaploid, it has three orthologues of barley *Mlo* (*TaMlo-A1*, *B1* and *D1*). Wang *et al*. used TALEN and CRISPR to edit these wheat *Mlo* genes and found that the edited plants exhibited resistance towards the powdery mildew fungus *Blumeria graminis* f. sp. *tritici* (*Bgt*) only when all six copies of *TaMlo* were simultaneously mutated.

Resistance against Viral Pathogens:

Plant viral diseases are difficult to manage because viruses evolve rapidly and because insect vectors are usually involved. During the past three decades, transgenic expression of virus proteins or RNAs has been widely used to improve plant virus resistance, and the resultant resistance is called pathogen-derived resistance. Recently, RNAi induced by double-stranded RNA has also been considered an efficient method to confer resistance against viruses to plants. Genome editing technology provides a new weapon in the arsenal against plant viruses.

Previously, an artificial zinc finger protein (AZP) without a nuclease domain was generated to target the replication origin of the Beet severe curly top virus (BSCTV) by blocking the binding of viral replication protein (Rep). Transgenic AZP *Arabidopsis* plants showed increased resistance to BSCTV, and more than 80% of these transgenic plants exhibited no viral infection symptoms (Sera T. 2005). Similarly, ZFNs have been designed to target a conserved region of the Rep gene of Tomato yellow leaf curl China virus (TYLCCNV) and the Tobacco curly shoot virus (TbCSV). A transient assay in tobacco demonstrated that these ZFNs cleaved the target sequences and inhibited replication of the viruses. TALENs were also used to generate transgenic tobacco with resistance to TbCSV, TYLCCNV and Tomato leaf curl Yunnan virus (TLCYnV) by targeting the Rep genes.

Advantages:

With the help of gene editing tools and technologies, various fields and areas have been covered that can help in the generation of precautions and methods in the treatment of different diseases. Through this process various researchers and scientists got the opportunity to treat many diseases. Researchers can cut the DNA at specific sites wit the help of nuclease and can join the fragments with the help of biological scissors which are widely used in the process of gene editing.

Challenges:

One of the major challenges related to genome editing technology is related to technical issues that arise during the engineering of the DNA of interest. Various ethical concerns are related to the implementation of gene editing techniques as well as bioethical issues that can affect the working of the gene editing technology. Also the major disadvantage of such tools and technology is that process is very expensive as well as the reagents that are used in the process is not easily available as well as very costly.

Conclusion:

Genome editing has great potential to overcome the limitations of conventional resistance breeding. First, a target gene in elite varieties can be directly modified by genome editing, thus bypassing the mating procedure. Second, if the target gene is determined, it is independent of plant populations with sufficient genetic variation; only sequence information of the target gene is required. Third, genome editing will not introduce changes beyond the target sites, thus avoiding

the potential problems of linkage drag. Fourth, resistance breeding with genome editing does not require genetic crosses and segregant progeny selection, thus driving rapid advancements.

Currently, most disease-resistant crops against non-viral pathogens are generated via genome editing through targeted mutagenesis of genes that negatively regulate defence, the so-called S genes.

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DIAGNOSIS AND IMPROVEMENT OF POTASSIUM DEFICIENCY IN CROPS FOR HIGH YIELD AND QUALITY

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Abstract

Potassium (K) is an essential nutrient for plant growth. Plants take up large quantities of K as compared to other macronutrients during their life cycle. Potassium, unlike other nutrients, does not form compounds in plants but remains free to 'regulate' many essential processes. This includes enzyme activation, photosynthesis, water-use efficiency, starch formation, and protein synthesis. Most crops contain about the same amounts of nitrogen and potassium, but potassium content of many high-yielding crops is even higher than that of nitrogen. Most soils contain large amounts of potassium, but only a small portion is available to plants over a growing season. A basic understanding of K, including plants' K nutrition, how it reacts in soils, its roles and deficiency symptoms in plants, and its roles in efficient crop production and produce quality is being highlighted in this paper.

Introduction

Potassium is one of the three main pillars of balanced fertilizer use, along with nitrogen (N) and phosphorus (P). Soil test results for potassium (K) fertility status among India's soils are categorized as 21% low, 51% medium, and 28% high. Despite high crop demand, K fertilization still being neglected or severely inadequate in Indian agriculture. Lack of farmers awareness about the importance of K is the major cause of neglecting its use resulting in poor yield and poor produce quality. All efforts should, therefore, be made to create greater awareness among farmers about the importance of K in plant nutrition and incurring losses due to neglecting it. This assumes great importance in view of the fact that they may not realize the benefits of applied K at early stage of crop growth, for example, its effect on the abiotic and biotic stress, size, shape, colour, and quality of produce, which they may realize at maturity, so its need may be overlooked. In contrast, the benefits from N and P are more readily apparent from initial stages of crop growth. Another reason for inadequate use of K fertilizers may be the lack of crop response to applied K, sometime even on low K testing soils. However, soils rated as high can also show significant responses to applied K in certain soils, crops, cropping systems and climatic situations. Thus, soil test methods for categorizing soils into low, medium, and high K values need further refinement for better soil test/crop response correlation.

Role of potassium in plants

Potassium (K) is involved in many essential functions in plants. Once taken up by the plant, K^+ does not become part of complex organic molecules, instead it is a highly mobile free ion that is most known for its role in regulating water pressure in plant cells, affecting cell extension, gas exchange, and movement of leaves in response to light. Other roles include the activation of

enzymes that help chemical reactions take place, assisting with protein synthesis, pH regulation within cells, and enhancing photosynthesis. Potassium also assists with the transport of chemical compounds around the plant. Plants that are supplied with adequate K are better equipped to withstand abiotic (and biotic stresses caused by pests and diseases compared to plants with a low supply of K.

Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production. The production of ATP can regulate the rate of photosynthesis. Potassium also helps regulate the opening and closing of the stomata, which regulates the exchange of water vapor, oxygen and carbon dioxide. If K is deficient or not supplied in adequate amounts, it stunts plant growth and reduces yield. Other roles of K include:

- Increases root growth and improves drought resistance.
- Maintains turgor; reduces water loss and wilting.
- Aids in photosynthesis and food formation.
- Reduces respiration, preventing energy losses.
- Enhances translocation of sugars and starch.
- Produces grain rich in starch.
- Increases plants' protein content.
- Builds cellulose and reduces lodging.
- Helps retard abiotic and biotic stresses.
- Necessary for the formation of sugars and starches
- Essential for oil production
- Enzyme activator
- Improves cold weather tolerance

Potassium Deficiency Symptoms

When potassium uptake is inhibited, plants may exhibit these common potassium deficiency symptoms.

1. ***Yellowing leaves:*** Yellowing that occurs between the leaf margins is known as chlorosis. This condition commonly affects older leaves and lower leaves first before spreading to younger leaves. If left unchecked, it will lead to leaf necrosis (death).
2. ***Wilting leaves***: Potassium helps create pressure within plant cells, which prevents the leaves from wilting. When potassium levels are low, plant leaves are prone to wilting.
3. ***Burnt leaf edges:*** When the edges of a plant's leaves become scorched or burnt looking, it's likely due to a potassium deficiency.
4. ***Purple spots:*** The presence of purple spots on the underside of leaves is another common sign of potassium deficiency.
5. ***Slow growth activity****:* Potassium is an essential contributor to root growth, which means new growth will be slow and crop yield will be stunted in potassium-deficient plants.

Symptoms of Potassium Deficiency in Major Agricultural Crops

Some crops exhibit characteristic deficiency symptoms when adequate amounts of K aren't available for growth and development. Potassium is mobile in plants, and will move from lower to upper leaves. Following are photos and descriptions of K deficiency for several major crops.

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Maize: For maize (corn), the margins of the lower leaves turn brown (**Picture 1**). This development of dead tissue is accompanied by a striped appearance in the rest of the leaf. The entire leaf has a very distinct light green appearance when viewed from a distance. Later on firing or scorching appears on outer edge of leaf, while midrib remains green. May be some yellow striping on lower leaves. Poor root development, defective nodal tissues, unfilled, chaffy ears, and stalk lodging are other symptoms in maize. The cobs of K-deficiency plants are narrowed and peaked. Grains in the cob tips are only poorly filled.

Wheat: Frequently, out- standing hunger signs on leaf itself (no discoloration, scorching, or mottling), but sharp difference in plant size and number, length, and condition of roots. Lodging tendency and smaller ears are observed. In advanced stages, withering or burn of leaf tips and margins of the older leaves which are the characteristic symptoms, could be seen **(Picture 2).**

Picture 1: Potassium deficiency symptoms in maize showing chlorosis along the leaf margin at early stage (Left), later on firing or scorching (Middle) and poor grain filling in upper part of cobs (Right).

Picture 2. Potassium-deficiency symptoms in Wheat

Rice: Rice deficient in K may show symptoms as stunted plants, a slight reduction in tillering, and short, droopy, dark green upper leaves. Yellowing may appear in interveinal areas of lower leaves, starting from the top and eventually drying to a light brown. Long, thin panicles and black, deteriorated roots may be related to K deficiency **(Picture 3).**

Picture 3. Potassium-deficiency symptoms in Rice

Pearl millet: First of all, the margins of the lower leaves turn yellow then the entire leaf has a very distinct light green appearance when viewed from a distance. The yellow margins later on become brownish. Later on firing or scorching appears on outer edge of leaf, while midrib remains green (**Picture 4**).

Picture 4. Potassium-deficiency symptoms in Pearl millet

Mustard: Potassium deficiency reduces growth, resulting in smaller leaves and thinner stems. Plants are more easily lodged and may wilt. Under severe deficiency, the edges of older leaves become yellow, or scorchedand may die completely, but remain attachedto the stem. In brassicas, leaves are blue-green in colour and may have a low degree of interveinal chlorosis. Scorching along the outside edges of leaves is common, and leaves are often tough in texture due to slow growth **(Picture 5).**

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Picture 5. Potassium-deficiency symptoms in Mustard

Peanuts: Because K is easily redis tributed from mature to younger organs, deficiency symptoms are first observable in the older, lower leaves. Deficiency is expressed by chlorosis of the leaves, beginning at the leaf margin **(Picture 6)**. Potassium deficiency occurs frequently in acidic soils, and symptoms usually appear within five weeks of planting.

Picture 6. Potassium-deficiency symptoms in Peanuts plants (Left) and Kernels (Right)

Soybeans: Green plants with chlorosis along the leaf margins leading to brown interveinal necrosis in soybean; veins stay green. Symptoms appear first or are more severe on older and/or fully expanded leaves **(Picture 7)**. Symptoms are localized on leaves. Firing or scorching begins on outer edge of leaf. When leaf tissue dies, leaf edges become broken and ragged, delayed maturity and slow defoliation, shriveled and less uniform beans, many worthless. Firing or scorching begins on outer edge of leaf. When leaf tissue dies, leaf edges become broken and ragged, delayed maturity and slow defoliation, shriveled and less uniform beans, many worthless.

Picture 7. Potassium-deficiency symptoms in Soyabean: Chlorosis on the margin (Left) and later on scorching (Right)

Egyptian Clover (Berseem): With classical symptoms (shown at top right), first signs of K deficiency are small white or yellowish dots around outer edges of leaves, then edges turn yellow and tissue dies and becomes brown and dry. However, for Egyptian clover grown on soils high in sodium (Na), the K deficiency symptom has a different appearance, as indicated in **Picture 8**.

Picture 8. Potassium-deficiency symptoms in Egyptian Clover

Cotton: Cotton "rust": first a yellowish or bronze mottling in the older leaves. Leaves turn yellowish green, brown specks at tip around margin and between veins. As breakdown progresses, whole leaf becomes reddish brown, dies, sheds pre-ma turly, short plants with fewer, smaller bolls of short, weak fibers **(Picture 9)**.In the past, K deficiency symptoms have been described as occurring on older, mature leaves at the bottom of the plant. In recent years, symptoms have been observed at the top on young leaves of some heavily fruited cotton varieties.

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Picture 9. Deficiency symptoms in Cotton (Left) and a cotton field exhibiting potassium deficiency symptoms (Right).

Correcting Potassium Deficiency

Sources of Potassium (K): The available sources for K fertilization through soil are muriate of potash (MOP) and sulphate of potash (SOP). MOP is preferred over SOP because of its low cost. MOP has the highest K_2O equivalent at 60%. The other K sources are mono potassium phosphate (0:52:34), potassium magnesium sulphate (sul-po-mag) (22% K, 11% Mg) and poly-halite (Poly 4) dihydrated potassium, calcium, and magnesium sulphate ($K_2Ca_2Mg\ (SO_4)_4 \cdot 2H_2O$). Poly-halite has 19.2% S, 14% K_2O (11.6% K), 6% MgO (3.6% Mg) and 17% CaO (12.2% Ca), all in available form for plant uptake. Recently, a new fertilizer wherein the potash is derived from the molasses, a by-product of sugar mills named as Natural potash (14% K_2O) is also available in the market. Besides, a few fully water soluble NPK grades (18:18:18, 19:19:19) are available for foliar spray and fertigation. Wood ash also has high potassium content but must be used cautiously due its effect on pH level. Adequate moisture is necessary for effective K uptake; low soil water reduces K uptake by plant roots. Liming acidic soils can increase K retention in some soils by reducing leaching.

Use of Potassium: The K fertilizer can be applied through preplant broadcasting, preplant banding, or side-dress after emergence. After broadcasting, incorporating fertilizer in the soil facilitates K uptake. The amount of K fertilizer applied should follow the soil test recommendations. K fertilization is done in preplant single application. This practice is easy and cost-effective because of the reduced number of trips over the field for fertilization. However, several problems are associated with single application because a large amount of applied K is prone to leaching, especially in sandy soils. Early-season single K application can also result in late-season K deficiency because K demand is higher during the ear emergence, flowering, boll setting, and most K uptake occurs after flowering. Additionally, K is not actively mobile in soil. Therefore, roots must intercept K in the soil for the uptake to occur. However, root activity is reduced after flowering. Considering the sandy soils, this problem can be managed via split K application by applying one-third at planting/seeding, one-third at tillering and remaining one-third at panicle initiation/flowering to meet K requirements of crops.

As in India, in cereals, pulses and oilseeds, K is applied in very low quantity, the strategy can be preplant single K fertilization coupled with mid-season foliar K application. Potassium sulphate

and potassium nitrate (KNO_3) are the preferred fertilizers for foliar application because of their high solubility. Foliar K application can be beneficial to mitigate late-season K deficiency. Foliar K application needs to be considered on soils with high sand content, and low K when early-maturing varieties are used.

Potassium deficiency in standing crops can be corrected quickly by foliar spray of 1% solution of high K containing fully water-soluble potassium sulphate (0:0:50), potassium nitrate (44%) or mono potassium phosphate (0:52:34) @ 10 gm/litre water to correct severe K deficiency. NPK grades (18:18:18, 19:19:19) can be used for foliar spray @ 10 gm/litre water to correct mild K deficiency. Soil application of muriate of potash, Poly halite (Poly 4), K– Mag etc. @ 40-60 kg K_2O/ha can help correcting K deficiency. There are several ways to naturally add K to the soil including composting, using green manure and wood ash to correct K deficiency in plants.

Epilogue

Apparently, a serious attitude towards K application is still lacking among farmers and extension workers. There is an urgent need to educate both about the importance of K in Indian agriculture for nutrient balance and efficiency, top crop yields and quality, and farmers profitability. Since the introduction of high yielding varieties of food grains in the 1960s, tremendous progress has been made in fertilizer use but mostly in respect of urea and DAP resulting high yield which can be further be increased significantly with the application of K and other nutrients which are deficient in soil in a balanced and efficient way. The increasing use of urea and DAP on a continued basis and higher production of food, fibre, and other crops also results in much higher removal of nutrients from soils. Hence, we should comprehensively assess the alarming situation of soil K mining and tell farmers about mining of K and its adverse effect on soil fertility and productivity and come up with appropriate solutions. Clearly, expansion in fertilizer application (input) continues to fall short of nutrient removal (output), resulting in depletion of soil fertility and negative nutrient balance. The situation cannot go on forever and strikes at the very root of sustainable agriculture.

Intensive research is needed to consider exchangeable and non-exchangeable K, and K-fixing capacity of the soils under different soil-crop-climatic conditions. An increasing number of farmers throughout India intend to harness full potential of improved cultivars to produce maximum economic yields. Understanding soil nutrient status and corrective fertilizer management practices to support high yields of high quality requires a continuation of refined scientific information and broadly based education programs for the farm advisory service, soil and plant testing laboratories, trainers, the mass media, and ultimately the farmer.

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BIOFILM – A NEW GENERATION BIOFERTILIZER

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Introduction

Our soils have become depleted and tired because of the frequent and ongoing use of synthetic fertilisers. Furthermore, leaching and instability cause most fertilisers to be lost, and their usage efficiency is low. The low organic matter content and consequently low microbial activity in the soil have also decreased its fertility. There is also a plateau in the yield level graph. More than ever, switching to organic and natural agricultural methods is necessary for environmentally sound, high-yield, and quality production.

Biofertilizer

In sustainable farming, biofertilizer is an effective substitute for chemical fertilisers in raising crop output and soil fertility. Biological fertilisers are a crucial component for guaranteeing the long-term sustainability of soil production since they have the potential to be both economically and environmentally beneficial for farmers. They would safeguard the environment as well. Although uses of chemical fertilizers are gradually oppressed by judicious application of alive microbial cultures, farmers in developing countries cannot rely exclusively upon traditional bio-fertilizers due to their shorter shelf life and crop specificity. Potential biological fertilizers would be essential to the productivity and sustainability of soil, as well as to environmental conservation because they are both environmentally beneficial and economical inputs for farmers. Utilizing bio-fertilizers allows plants to better absorb nutrients, thrive, and resist environmental stresses such as drought and pests. The benefits of using biofertilizer are depicted in the figure 1. Biofilm biofertilizer is a new generation biofertilizer and it is more effective in increasing crop yields and more resilient to environmental stresses, predators, and antagonists than traditional biological fertilisers.

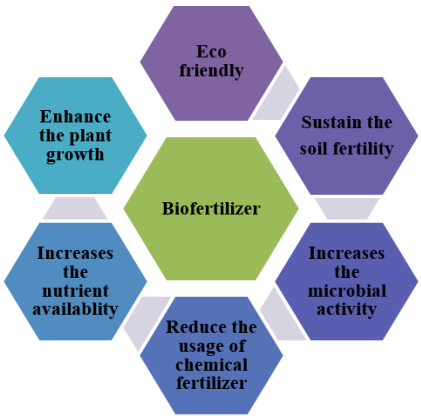


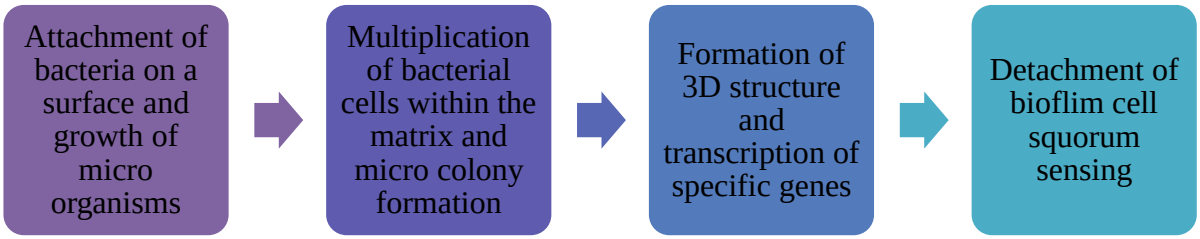
Fig.1 Benefits of using bio-fertilizers

Biofilm

Biofilm is defined as a well-organized structure formed by a microbial community assemblage that is enclosed in a self-produced matrix in which cells communicate (Armbruster and Parsek, 2018). Biofilms can be mono or multi-layered with single or multiple species of bacteria within the matrix associated with a particular surface. Biofilms are characterised as diverse colonies of a broad range of microorganisms that develop on or around the roots of plants. Biofilms can create communities that are beneficial detrimental, or pathogenic. Anywhere surfaces come into touch with water, biofilm forms. Microbes in biofilm form cooperative symbioses with other microbial cells and are sessile, covered in an extracellular polysaccharide (EPS) matrix. Because of symbiosis in biofilm construction and physiological adaptation, biofilms show greater microbial efficacy and can persist in various environments compared to a single free-living planktonic form. In a free-living condition, individual cells in a biofilm have different physiological and metabolic capacities. Some crops include root-bound beneficial biofilms that help with nutrient cycling, plant growth promotion, chemical production (like IAA), and biocontrol of pests and diseases.

Development of Biofilm biofertilizer

Selecting bacteria that are resistant to antibiotics is standard procedure when it comes to biofilm formation. Bacteria attach themselves to the substrate to start the process of creating micro-colonies, which causes the microorganisms to multiply quickly. Here, specific genes from the interacting bacterial cells are transcriptionally transcribed to form extracellular polymeric substances (EPS), which are composed of lipids, proteins, carbohydrates, and nucleic acids. The extracellular matrix may be produced because of the attachment process. The biofilm becoming anaerobic as the EPS thickness increases, and any newly formed daughter cells are eliminated by polysaccharide-cutting enzymes. Bacteria frequently stop EPS synthesis and separate into the environment via "quorum-sensing," which promotes communication between intra- and interspecies, to stop the growth of biofilms and harmful gut flora. It is crucial to consider factors such as the development profiles of the bacteria, the many types of organisms and their ideal settings, and the formulation of the inoculum to transform biofilms into bio-fertilizers. The process of creating biofilm bio-fertilizer consists of four phases.



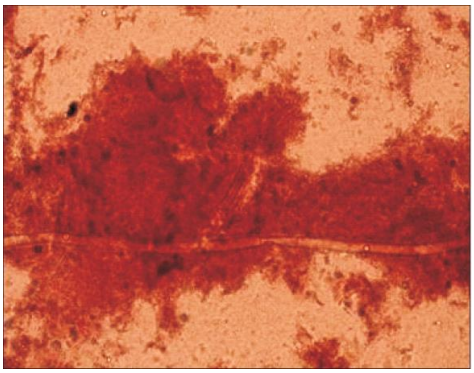
Characteristics suitable for carrier material

The following characteristics are crucial for a suitable carrier material. It must be reasonably priced, easily accessible, and have an adequate supply on hand. It should be simple to sterilise using autoclaving or gamma irradiation. It must be easy to process, free of lump-forming chemicals, and non-toxic to the plants and microorganisms to which it is administered. It must

take up a lot of water. It is necessary to be able to hold at least 50% of its water. The substance should adhere nicely to the seeds. It needs to be capable of functioning as a pH buffer (Pandit *et al*, 2020).

Biofilms biofertilizer

Fungal-bacterial biofilms are the resultant biofilms that are named after the bacteria that colonised and linked to fungal mycelia (FBB). Fungal-rhizobia biofilm (FRB) is the term used when the bacteria are rhizobium species. It was discovered that the FRB interaction fixes N_2 biologically. Nitrogen in the soil is fixed by cyanobacteria, aiding in plant growth. It has been shown to have many biologically active chemicals. In the soil, they perform the function of diazotrophs. A novel idea was created and tested in a variety of crops to create bio-filmed biofertilizers employing agriculturally significant microorganisms (N_2 fixer, P solubilizer, and other PGPRs) in a cyanobacterial matrix. In natural settings, cyanobacteria that are free-living form loose associations with other microorganisms in the form of biofilms. This is because the cyanobacteria's extracellular mucilage/polysaccharide layer provides an environment rich in nutrients for the growth of associated bacteria, both photosynthetic and non-photosynthetic types. Beneficial bacteria that colonise roots and stimulate plant growth are called rhizobacteria. Through the provision and production of phytohormones, they are known to directly promote plant development (Roy and Chakraborty, 2023). Nitrogenase activity, IAA production, phosphate solubilization, siderophore production, and ammonia production are incredibly higher in biofilm PGPR. e.g., *Rhizobium leguminosarum, Agrobacterium sp., A. vinelandii, Enterobacter cloacae, Xanthomonas sp., Pseudomonas sp., P. polymyxa, Bradyrhizobium sp., Bacillus subtilis, and B. drentensis.*



Trichoderma viride* with *Bacillus sp.

Anabaena torulosa* with *Azotobacter spp.

Conclusion

Soils have not accumulated enough nutrients because of farmers applying excessive amounts of chemical fertilisers without proper control during intensive agricultural operations. Through several mechanisms, including biological nitrogen fixation, nutrient mineralization and solubilization, plant hormone production, insect and disease management, and stress tolerance, biofertilizers support plant development and growth. The bacteria in biofilms biofertilizers can support the biological system because, when in bio-film mode, they can participate in a broad range of chemically and metabolically regulated functions. Finding a long-term substitute for chemical inputs, is crucial given the escalating health and environmental concerns and the need to increase global food production to meet the demands of an expanding global population. In this

way, biofilms biofertilizers have numerous advantages for environmental preservation in addition to being highly beneficial for sustainable agriculture.

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APPLICATION OF OILSEED CROPS RESIDUES IN AGRICULTURE AND TEXTILES

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Introduction

Oilseeds are seeds are cultivated mainly for their edible oil content. The oilseed crops include edible oilseeds & non edible oil. The edible oils are rapeseed & mustard, groundnut, soybean sunflower, sesame, niger, safflower, coconut, cotton seed oil etc. Castor seed oil and linseed (Flax) oil are the non-edible oilseeds. Soybeans and peanuts both fall within the larger category of oilseeds. Edible oilseeds and non-edible oil are among the annual oilseed crops.[1] Crop residues are the leftover waste products from farming. Field residues and process residues are the two categories of crop residues. Agriculture industry is producing agricultural waste in million tonnes annually. One of the biggest challenges is managing solid waste effectively and making the best use of this residues[2]. From oilseed crops cultivation also lots of crop residues are produce which are waste and pollute the environment. This waste can be used use judiciously to in textiles field. In order to fully utilize the idle and underutilized resources that contain enormous economic potential for India, all stakeholders must come up with creative and sustainable solutions. The textile sector recognizes a comparable difficulty and similar challenge is being acknowledged by the textile industry too which is second major sector providing employment in India[2]. In this article the potential application of oil seed crops residues in textiles in a sustainable ways.

Needs of crop residues in agriculture

Materials remaining in an agricultural field or orchard following crop harvesting are known as field residues. These remnants consist of seed pods, leaves, and stalks and stumps (stems). Effective field residue management can improve irrigation effectiveness and erosion control. The leftover material might be burned first or plowed straight into the earth. In contrast, the goal of no-till, strip-till, or reduced-till agriculture techniques is to increase the amount of crop residue cover. The oil seed crop residues can be wisely used by covering the land and shielding it from the effects of wind and rain, crop waste aids in the prevention of soil erosion. It is also essential for retaining moisture since it lessens runoff and encourages water to seep into the soil. Crop residues can be utilized as a feedstock in the thermo-chemical gasification process to produce syngas, or synthetic gas, which is hydrogen and carbon monoxide. Syngas can be used to make ethanol, gasoline, and diesel in addition to producing energy and certain chemicals. Materials left over after the crop is transformed into a useful resource are known as process residues. These leftovers consist of roots, husks, seeds, bagasse, and molasses that can be utilized as soil and animal chow.

Uses of oil seed crops residues:

What remains after a crop is transformed into a useful resource is called a process residue. These residues include husks, seeds, bagasse, molasses and roots. They can be used as animal fodder and soil amendment, fertilizers and in manufacturing other value added products in agriculture

and textiles. Crop residues can be used effectively in many ways like bio-fertilizer, bio-fuel production, mineralization, biochar, application in textiles, particle board, paper broad, mulching, briquettes. The different oil seed crops residues that can be used in agriculture and textiles applications are cotton, flax, hemp, soyabean, coconut, mustard etc.These residues have similar structure, composition and properties to those of other plant fibres and make them suitable for application in composite, agro tech, geo textiles, packtech, automotive, nonwoven, textile/apparel and paper and pulp. The alternative uses of oil seed crops residue as fodder. Residue can be used in bio-thermal power plants; in mushroom cultivation, for bedding material for cattle; its use for production of bio-oil; paper production; bio-gas etc. The use of oil crops agro-residues can alleviate the shortage of wood resources in countries where there are few forestry resources.

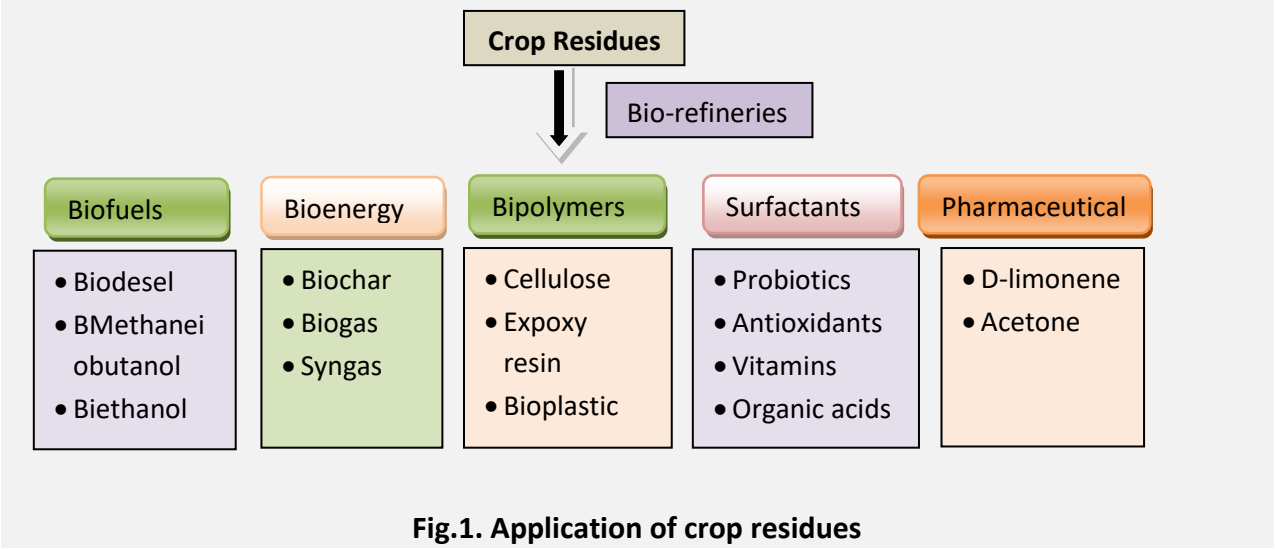


Fig.1. Application of crop residues

Cotton: The most commonly produced natural fiber in the world is cotton and is an oilseeds crop. They originate specifically from the cotton plant's seed coat, which is the outermost coating of the seeds. The cotton seeds must be extracted from the plant, and then the fibers from the seeds, before they can be made into sheets or t-shirts[3]. Essential cooking oil made from cotton plant seeds is called cottonseed oil. Depending on the species and quality of the seeds, whole cottonseeds can contain 15% to 20% oil[3]. Cotton is renowned for its performance, adaptability, and inherent comfort. Cotton is the perfect material for clothing and household items, as well as industrial items like tarpaulins, tents, hotel linens, army uniforms, and even the outfits astronauts wear inside space shuttles because of its strength and absorbency. Cotton fiber is used to weave and knit a variety of fabrics, such as jersey, flannel, chambray, velvet, and corduroy[4, 5].

Cotton plants **Cotton seeds** **Cotton seed oil** **Paper** **Sanitary napkin** **Ear buds** **Wicks**

Fig.2 Application of cotton in textiles

Flax: The inner bark of a plant cultivated in temperate and subtropical regions of the world is where flax fibers are extracted. It is a natural cellulosic, multi cellular bast fiber. Flax is two to three time stronger than cotton, making it one of the strongest natural fibers known. Textiles made from flax are known as linen and are traditionally used for bed sheets, underclothes and table linen. The flax oil is known as linseed oil used in furniture to protect against infestation of termite. The end uses of flax fibers are sail cloth, tents, shoes threads, sewing threads, handkerchief, towels, table cloth, sheets, garments, table wear, suiting, cloth apparel, surgical threads upholstery, wall covering, canvas, luggage fabrics, insulation, filtration, automotive end uses, reinforce plastic, composite materials board, fabric, aviation etc. The seeds and oil from the flax plant are used for food, animal feed, and industrial purposes, making it a valuable crop for farmers around the world.[6]

Flax plant **Flax fiber** **Processed fibers** **Flax yarns** **Flax Weaving** **Flax Fabric** **Flax Chair**

Fig.3. Uses of flax residues in textiles

Hemp fibers: Hemp fibers, as lignocellulosic raw materials show similarities to other bast fibers due to the comparable chemical composition of this fiber group. Fibers extracted from fibrous plant stalk contain cellulose, hemicellulose lignin, pectin, wax, fats and ash etc[7].The Cannabis sativa plant species, which is mostly grown for industrial purposes, is the source of hemp fiber. Hemp is a fast-growing annual herbaceous plant with strong, naturally occurring bast fibers that are inexpensive. Hemp fibers are appealing for use in chelating materials, composite materials, and wool insulation due to their characteristics of being lightweight, rigid, and durable. Textiles, building, paper, composites, and animal beddings are the main industries using hemp fibers. France, China, Canada, and US are the top hemp-growing nations[8]. Hemp is used to make many commercial and industrial products, including

Hemp plants **Hemp stalk & fibers** **Hemp fibers** **Hemp yarns** **Non Woven Hemp** **Automotive**

Fig.4 Different application of Hemp in textiles and allied

ropes, textiles, clothing, shoes, food, paper, bio-plastics, insulation, and biofuel. Hemp fibers can be used to create cords and ropes because of their high tensile strength. As strange as it may sound, strong shoes that are comfortable and long-lasting have been made using hemp fibers[9,10]

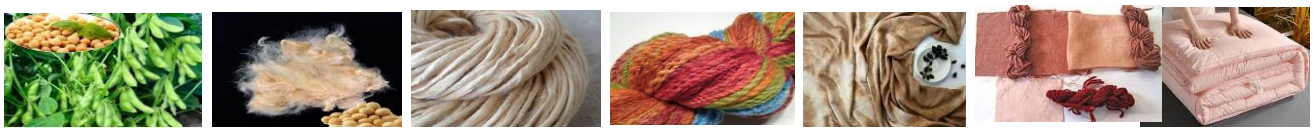
Coconut: Coconut is another oil yielding crops and coconut fiber is the most well-known fibrous waste from the coconuts cultivation. Coir is a desirable material for a variety of applications because of its strength, durability, and adaptability. Coconut fibers are a natural fiber extracted

from the outer husk of coconut which is taken from the unripe coconut husk. After steeping the coconut in hot seawater, the fibers are combed and crushed to remove the shell[11]. Coconut fibre has a wide range of uses in various industries due to its unique properties like strength, durability, elasticity, and biodegradability. Coconut fibers are used in products such as floor mats, doormats brushes and mattresses, twine and cordage, rugs, mats as a cushion filling for furniture and car seats[12]. Coir is sustainable natural resources and it has a wide range of application in industries such as agriculture, textiles and construction. Coir provides superior water retention and aeration qualities, making it a successful soilless growing substrate for plants. For the textile business, coir is a desirable substitute for synthetic materials because to its strength, durability, and biodegradability[13].

Coconut plant **Coconut husk** **Coir** **Uility artcles** **Non Woven** **Floormat** **Coconut Pots**

Fig. 4. Uses of coconuts fibers in textiles and others

Soybean fibers: The bean of the soybean plant, a kind of legume native to East Asia, is not only edible but also has a variety of applications. The soybean plant can be utilized to produce textile fibers based on both proteins and cellulosic materials. From soybean textile fibers can be extracted and is sustainable. The soybean protein fiber is actually made from the by-product leftovers of soybean oil/tofu/soymilk production. Soybean gives cashmere-like texture and often referred to as "vegetable cashmere," "artificial cashmere," and "soy silk" which are naturally cream or pale yellow in hue it can be blended with cashmere. It enhances the smooth quality and easy care properties. Soybean is one of those promising renewable, sustainable, and biodegradable fibers which combine benefits for the environment with acceptable textile performance. Soybean fibre is a man-made regenerated protein.



Soybean plants **Soybean fibers** **Soy slivers** **Soy yarn** **Soy fabrics** **Soy fabric** **Soy Duvet**

Fig.5. Use of soybean crop residues in textiles

fibre from soybean protein blended with PVA[14]. Soy protein fibers are utilized in agriculture and the food sector for a variety of purposes, including food and feed. In various industries, it is utilized for adhesives, emulsions, cleaning supplies, pharmaceuticals, inks, and plastics. Fiber is utilized in the textile industry to make home textiles as well as clothing[15].

Conclusion: The appropriate use of the readily available and compatible natural resources and its crop residues are necessary for the development of a sustainable industry. Although textile application offers a relatively high value addition and a huge market for consumption of fibers from agro residues, they require of high quality, existing extraction methods need to be

supplemented with robust techniques and machinery to provide the agro residues with value worth advocating. In a monetized economy, even where residues are freely available everything which has a use will sooner rather than later acquire monetary value.

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MUSHROOM: A SUPERFOOD FOR ACHIEVING NUTRITIONAL SECURITY IN INDIA

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Abstract
Mushrooms, often known as superfood, offer a variety of vital nutrients such as vitamins, proteins, minerals, antioxidants, etc. Mushrooms have unique bioactive compounds, thus contributing to health benefits such as boosting immunity, preventing coronary and other chronic diseases. The study explores and presents the potential of mushrooms to improve nutritional security, particularly for those with limited dietary diversity i.e. Indian population. By incorporating mushrooms into daily diets, various micronutrient deficiencies can be addressed, thus supporting sustainable food systems. The findings highlight the importance of mushroom farming and consumption as a feasible tactic to improve human health and achieve global nutritional security.

Key words : Mushrooms, superfood, nutrients, bioactive compounds, nutritional security, public health

Introduction

As economic reforms gained momentum, India's Gross Domestic Product (GDP) growth rose five-fold to reach 3.9trillion USD in 2023 (International Monetary Fund, 2024). During 2018-21, compared to China (8.11%), India's annual economic growth rate was at 8.95%, which made us one of the fastest growing economies. Irrespective of the rapid economic growth and considerable increases in food grains production, India has not yet become nutritionally secured nation. Food and nutritional security is among major policy challenges which further put pressure on human well-being in the form of increasing poverty, poor health, low levels of education and skill, and a poor quality of life. Although, the incidence of undernutrition in India has reduced significantly in the past two decades, however as per the latest survey of International Institute of Population Sciences (IIPS and MoH&FW), 2017, about 44% children still suffer from various forms of malnutrition in India. Hence, there is a strong need to approach these major problems comprehensively through strategies such as diversification of income sources and diets.

Agriculture sector challenges and food security status in India

Agriculture sector is one of the lively sectors of the Indian economy and its role in the socio-economic transformation of India hardly needs any explanation. India also registered a record production of food grains, horticultural crops, and so also, livestock, and fish. Despite these endeavors, agri-sector is encountering various challenges in terms of low productivity, shrinking land-holding size, climate change, risks and weather uncertainties etc. (Pathak, 2019). There is a significant decline in its contribution to gross value added (GVA) from 29% (1990- 91) to 17.7% (2023-24) (Government of India (GoI) a, 2024). There has been continuous increase in population, which along with rising incomes and an ensuing shift in consumer preferences towards resource-

intensive high-valued and nutrient rich products imposes a considerable load on already shrinking natural resource base. Thus, we are fronting dual challenges of improving productivity to ensure profitable farming on one hand and maintaining the resource sustainability on the other. Moreover, these challenges will further be aggravated in the near future as the population of India is projected to rise from present 1.4 billion to 1.6 billion by 2050, surpassing China (United Nations, 2017), which will lead to a drop in per capita food availability.

As per International Food Policy Research Institute report, Global Hunger Index (GHI) 2024, India ranked at 111thposition among 125 nations with a score of 28.7 indicating hunger as a serious problem in the country. Similarly we performed moderately in terms of Global Food security Index (GFSI), 2024 with 68thrank among 113 countries as per the GFSI published by Economist's Intelligence Unit which covers almost all the aspects such as affordability, availability, quality and safety, and natural resources and resilience. Although in the past two decades, India has come a long way in tackling hunger and food insecurity, yet this stride of change is neither even nor inclusive. Hence, food and nutritional insecurity is thus an urgent concern to the Indian economy as well as a long-term threat to the well-being of natives.

Food grains alone cannot achieve nutritional security

According to Ministry of Agriculture report the predicted demand of food grain was 275 MT in 2016-17 while the actual production was just few million tons than the predicted value and was not considered sufficient in case of unforeseen contingencies such as drought. Although, for the past few decades, although food availability per head has increased but rise has not been ample. As per recent Economic Survey, the net availability of food grains is increasing but sluggishly and has not been able to keep up with the pace at which our population is rising. In 2020, it was 187.1 Kg/ year which is much lower than developed nations like China, America, and even less developed neighboring countries like Bangladesh. There has also been a slight decline in food grain production from last year due to delayed and poor rains (GoI b, 2024). Apart from this, food grains are deficient in essential vitamins and minerals such as Vitamin A, C, B_{12}, and D, minerals such as calcium and sodium which are vital for human health. Certain anti nutritional factors such as trypsin inhibitor, polyphenols, and phytate reduce the bioavailability of some minerals present in cereals and legumes (Nadeem et al., 2010), thus reducing the ability of foodgrains to cater to nutritional security alone.

Mushrooms have recently been added in Indian diet and their per capita consumption is now increasing. Despite of this, we are lagging far behind many developed nations in terms of per capita consumption. It is around 240 grams in India as compared to 2-3 kg per capita per year in America and Europe. Edible mushrooms have numerous beneficial qualities and there is an insistent need of utilizing these mushrooms as healthy and nutritious food to their full potential which is underutilized.

Mushrooms for food and nutritional security

Due to good nutritive value, higher fungi fructifications have been used as food. Traditionally mushrooms were consumed just for their unique flavor, but presently due to a various research on their chemical compositions, it has been known that they contain many nutrients and bio-active compounds which can help in improving nutrition status of its consumers. Mushrooms are fat free low carb source of food rich in proteins and other important minerals. There is a vast

opportunity for presenting and selling mushroom as a health food, targeting nutritional security in India. Mushrooms have high protein (35-40%), carbohydrates (40-60%), vitamin B complex, vitamin D, and fibre (8-10%). Mushrooms are good source of minerals like Potassium, Selenium, Copper and low in Sodium which makes them good for hypertensive people. Mushrooms are sole source of vitamin D_2 for vegans. Mushrooms have very low fat (<1%) primarily unsaturated fats, including both monounsaturated and polyunsaturated fats (linoleic acid), which are considered heart-healthy fats. Mushrooms have no cholesterol, low glycemic index and calorific value making them suitable for diabetic and obese people. Medicinal mushrooms have various beneficial compounds, such as lentinan, lovastatin, cordycepin, β- glucan, triterpene, etc. Mushrooms have properties like: immunomodulating, antioxidant, cholesterol-lowering, antiviral, antibacterial, antidiabetic, antiobesity, neuroprotective effects, etc.

Mushroom production in India

Mushroom cultivation exploits the unused potential of our natural resource base and agro wastes. India produces more than600 million tons (MT) of agro waste annually, out of which we are utilizing negligible proportion to produce just 3.36 lakh tons of mushrooms annually.

Figure 1. Indian mushroom production (1970-2023)

The trend in Indian mushroom production in India is given in figure 1. The production of fresh mushrooms has increased from 0.005 MT (million tonnes) (1978) to 0.34 MT (2023). With this, India stands at number 3 in terms of mushroom production followed by China and Japan. The major share of this comes from single specie white button (70%) followed by oyster (17%) and paddy straw mushroom (9%).

A low-carb fat free food

Apart from undernutrition, many developed nations are suffering from obesity, diabetes, and heart diseases resulting from over-nutrition. Not only mushrooms are cholesterol free, but they also are potent source of chitin and beta-glucan fibers which further help in lowering cholesterol levels in the body. They contain about 22 to 296 kcal per 100 grams which is lower than most of the cereals and pulses (about 350 kcal per 100 grams). The energy requirement of an adult male is about 2550 kcal per day which can be met by consuming around half kg of white button mushroom without getting any side effects such as obesity. Apart from being low in fat, pink oyster and shiitake mushrooms also help in lowering the bad cholesterol levels of the body owing to presence of beneficial fibers such as chitin and beta-glucan (Riaz et al.,2022).

Superior proteins

The favorable protein content in mushrooms varies from 11% (wood decaying) to 35% (Agaricus species) on dry weight basis. This is greater than fruits, vegetables, and even cereals. In which the crude protein varies from 7% (Brown rice) to 11.6% (Pearl millets). Moreover, mushroom proteins are of superior quality as they are rich in lysine and tryptophan which are absent in cereals (Agarwal et al., 2017). These proteins are highly digestible (70-90%) which is more than vegetable proteins. As proteins are indispensable for human health, prompt inclusion of mushrooms in Indian diet will help in reducing undernutrition incidence in the country.

Boosts immunity

Mushrooms are high in vitamins in which traditional veggies are generally deficient. Some mushrooms contain high amount of vitamin B_{12} and vitamin D, a fat soluble vitamin which helps the body in nutrient absorption. Certain mushrooms such as Resihi mushrooms have considerable anti- inflammatory properties which further have many beneficial effects. Moreover mushrooms are rich in anti-oxidants specifically in ergothioneine, and glutathione, having anti-aging properties. These are highest in a species of mushroom known as *wild porcini mushroom.* Since mushrooms contain high crude fiber, crude protein content, superior vitamins and negligible cholesterol, *they are considered as very valuable food.* Hence, with all these benefits it will be just to call mushrooms as turbo shots for our immune system.

A more sustainable enterprise to achieve nutritional security

Although non-traditional, yet mushroom cultivation is more sustainable than growing other traditional crops. This is because mushrooms are grown on by products of crops such as wheat straw, paddy straw, cow manure, poultry manure, husks, corn cobs etc. Mushrooms also require lesser water than other crops. When it takes tens of gallons of water to produce other fruits and vegetables, mushrooms only require two to three gallons for one pound produce. Moreover the land requirement for mushroom farming is much less than other major crops. From a square foot of land, in general 7 pounds of mushrooms can be harvested and hence from an acre we can get about a million pound of mushrooms. All this because it is based on vertical farming and therefore conserves land which is a major issue in present day agriculture. Hence, their cultivation is more resource efficient along with having minimal environmental impact.

Conclusion

Undernutrition is a widespread and serious issue, with various nations failing to meet global nutrition goals. The challenge of nutritional security is multifaceted and hence, cannot be solved by food grains alone as they lack essential bioactive compounds and minerals, otherwise abundant in mushrooms. Mushrooms, often overlooked in traditional Indian diets, are incipient as a potent superfood due to their rich nutritional profile. They are excellent source of essential vitamins, minerals, and bioactive compounds such as antioxidants and beta-glucans, which have been known to enhance immune function and support cardiovascular health. Integrating mushrooms into the Indian dietary regime can significantly contribute to addressing nutritional deficiencies, improving overall health and achieving nutritional security in a sustainable manner.

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BINOMIAL DISTRIBUTION

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ABSTRACT
In probability theory and statistics, the binomial distribution is a discrete probability distribution that is used for generating trials that have two possible outcomes: success or failure. Test results (pass/fail) and coin flips (heads or tails) are frequent examples. Two possible results for each trial, a fixed probability of success, independent trials, and a set number of trials are the four main fundamental assumptions of the distribution.

Calculating the success event, success probability (p), total trials (n), and applying the binomial formula to apply the binomial distribution: nCr * p ^ r * (1-p) ^ (n-r) = P(r). The distribution's standard deviation (σ) is √(np(1-p)), variance (σ^2) is np(1-p), and mean (μ) is np.

INTRODUCTION
The binomial distribution, as applied in probability theory and statistics, is a discrete distribution of probabilities that provides only two possible results for an experiment: success or failure. For example, there are only two possible outcomes while tossing a coin: heads or tails. Similarly, there are only two possible outcomes while taking a test: pass or fail.

The binomial distribution is discrete when compared to the continuous normal distribution. The binomial distribution and normal distribution are very similar for large sample sizes. When there is a small chance of success and a huge number of trials, the Poisson distribution is an instance of the binomial distribution. This simplifies estimations for rare events easier. As compared to the number of successes in a specific number of trials, the negative binomial distribution highlights the number of failures prior to a particular number of successes.

Assumptions of the binomial distribution
If the following four hypotheses remain true, then the binomial distribution should be applied:

First assumption: There are only two possible outcomes for every trial.

Second assumption: Every trial has the same probability of success.

Third assumption: Every trial is independent.

Fourth assumption: The total number of trials (n) must be determined before the experiment. Every trial is an independent occurrence of the same experiment performed again.

Consider the following examples to understand the above assumptions,

1) There are always just two outcomes that can occur while tossing a coin 50 times: heads or tails.

2) There is a 0.5 probability that a coin will come out on heads on any given toss. The probability of success remains constant from one coin toss to the next.
3) The outcome of one coin toss has nothing to do with the outcome of another coin toss. Every toss happens on its own.
4) Let's assume you are conducting an experiment to determine how many times you can toss a coin to obtain a head. The total number of trials (n) is fixed at 50 if you choose to toss the coin 50 times. The occurrence of a head in these 50 tosses can then be calculated by applying the binomial distribution.

Calculation of Binomial Distribution

We can say that r follows a binomial distribution if all of the above-mentioned assumptions have been answered in the yes, we conduct n trials and let r = number of successes. The binomial formula can be applied in the manners that follow:

1) Determine the event of success.
2) Determine the success probability (p).
3) Determine the total number of trials.
4) Analyse the significant event using the binomial variable r.
5) Determination of the probability of every possible resulted by the application of binomial probability formula,

$\mathbf{P(r) = {}^{n}C_{r}\, p^{r}\, q^{n-r}}$,

and subsequently add these probabilities together, where the number of failures is n-r.

Binomial frequency distribution

The number of successes in a predetermined number of independent trials, each of which has an equal chance of success, is given by a discrete probability distribution called a binomial frequency distribution. The number of trials (n) and the probability of success on each trial (p) are the two parameters that characterize the binomial distribution. The binomial distribution's probability mass function (PMF) is given by:

$\mathbf{(p+q)^{n} = {}^{n}C_{0}q^{n} + {}^{n}C_{1}p^{1}q^{n-1} + {}^{n}C_{2}p^{2}q^{n-2} + {}^{n}C_{3}p^{3}q^{n-3} + {}^{n}C_{4}p^{4}q^{n-4} + \ldots + {}^{n}C_{n}\, p^{n}}$

Assume that if there are N sets of 'n' trails, then $N(p+q)^{n}$

$\mathbf{N(p+q)^{n} = N({}^{n}C_{0}q^{n} + {}^{n}C_{1}p^{1}q^{n-1} + {}^{n}C_{2}p^{2}q^{n-2} + {}^{n}C_{3}p^{3}q^{n-3} + {}^{n}C_{4}p^{4}q^{n-4} + \ldots + {}^{n}C_{n}p^{n})}$

Mean and variance of binomial distribution

The formulas below can be employed to represent the mean, variance, and standard deviation for a given number of successes in a binomial distribution.

Mean, $\mu = np$
Variance, $\sigma^{2} = npq$;
Deviation Standard $\sigma = \sqrt{(npq)}$

where p is the probability of success The probability of failure, q, is given by q = 1-p.

In a binomial distribution, p and q both are smaller than one but not equivalent to zero, and the variance is always less than the mean.

Difference between normal distribution and binomial distribution

The binomial distribution is discrete, on the other hand normal distribution is continuous. This is the primary difference between the two distributions. It shows that there are a finite number of

events in the binomial distribution and an infinite number in the normal distribution. The distribution curve of the binomial distribution matches the normal distribution curve when the sample size for the binomial distribution is large enough.

The relation between the Poisson and binomial distributions

In reality, the Poisson distribution is a limiting case of a Binomial distribution in conditions when p, the success probability, is very small (tends to zero) and n, the number of trials, becomes extremely large (tends to infinity). If $n \geq 100$ and $np \leq 10$, the Poisson distribution (with $\lambda = np$) can usually generate a very good measure of the binomial distribution. As an example, Let's imagine you are tossing a coin with a significant bias in favour of tails, meaning that the chance of receiving heads, or success, is extremely low—let's say $p=0.01$. You made the decision to toss a coin 1000 times. Because there are many factorials involved, calculating this directly using a binomial distribution can be challenging. Using the Poisson distribution, this is significantly easier to calculate and gives a near-binomial probability estimate.

Binomial vs negative binomial

The number of successes in a given number of trials is calculated by the binomial distribution, whereas the number of failures before a given number of successes is calculated by the negative binomial distribution.

As an example, the negative binomial distribution is used for calculating the probability of getting a specific number of heads in a coin-flipping experiment before a specific number of tails, while the binomial distribution is used for calculating the probability of getting a specific number of heads in a given number of coin flips.

Conclusion

A basic concept in probability and statistics, the binomial distribution provides a method to describe events with binary outcomes. Its basic assumptions ensure its application to a wide range of studies, including test results and coin flips. The distribution makes it simpler to study discrete events by giving calculations for probability, mean, variance, and standard deviation. Its application in large sample sizes and rare events can be shown by comparisons with the normal and Poisson distributions, respectively. Its application broadness gets broader by understanding the relationship between negative and binomial distributions. Studying the binomial distribution gives one the capacity for analytical thinking required to analyse and estimate results in binary situations.

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BIO-FORTIFICATION: ENHANCING NUTRITION FOR REDUCING MALNUTRITION

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Abstract

Bio-fortification is a viable and cost effective method of providing micronutrients to populations who may lack access to a variety of diet or other micro nutrient therapies. This agriculture based strategy correcting micro nutrient deficit through plant breeding has been shown to be effective in research. More than 20 million people in developing county farm households are currently cultivating and eating bio-fortified foods. There are three major hurdles to reaching one billion people with bio-fortified crops by 2030: (a) mainstreaming bio-fortified traits into public plant breeding projects. (b) increasing consumer demand and (c) integration of bio-fortification in public and private policies, initiatives, and investments. While many of the building components are in place, institutional leadership is required to keep this ultimate vision on track.

Background

Terrorism, economic inflation, and climate change have all become important challenges to a healthy and quiet living since the beginning of the twenty-first century. According to the World Health Organization (WHO), an estimated 2 billion individuals worldwide suffer from anaemia, which is caused mostly by a lack of iron in their diet. Bio-fortification of staple food crops has emerged as a potentially powerful solution to the problem of nutritional deficit.

Malnutrition:

Malnutrition, also known as malnourishment, is a disorder that occurs when a person consumes a diet that is deficient or excessive in nutrients, resulting in health concerns. Calories, carbohydrates, vitamins, proteins, and minerals are among the nutrients involved (WHO,2012).

Causes of malnutrition:

The easily available foods and drinks heavy in fat, sugar, and salt are to blame for the rapid growth in obesity in adults and children. Overweight is a problem that affects both affluent and poor countries.

Negative Impacts of Malnutrition- It affects:

The population's productivity, the country's mortality rates, the survival rate of children, as well as their learning abilities, all contribute to youngsters becoming unproductive in later life.

Global Malnutrition Problems:

Of the 7.6 billion people on the planet, 815 million are malnourished, 150.8 million are stunted children, and 2.01 billion adults are overweight or obese. (2018 FAO Global Nutrition Report)

Malnutrition Problems in India:

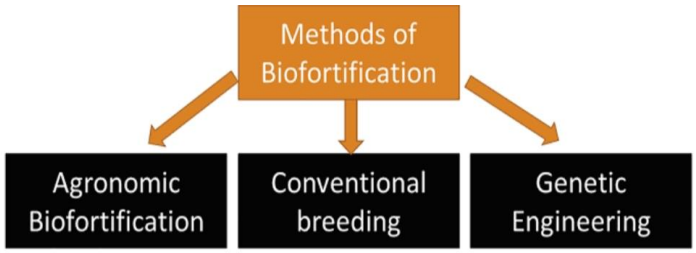
In India, 194.4 million people are malnourished. The Global Hunger Index 2018 ranks India 103rd out of 119 nations based on three key indicators: the prevalence of wasting and stunting in

children under the age of five, the under-five child death rate, and the proportion of the population that is undernourished. (The State of Food Security and Nutrition in the World 2019 Report by the FAO).

Introduction to Bio-fortification:

The term "bio-fortification" comes from the Greek word "bios," which means "life," and the Latin word "fortificare," which means "to strengthen." Steve Beebe (2001) created the word during a CIAT-sponsored meeting. Plant breeding, agronomic practises, and contemporary biotechnology techniques are all used to improve the nutritional value of food crops in the process of bio-fortification. The nutritional value of crops is boosted through bio-fortification throughout the plant growth stage, i.e., nutritional micro-nutrient content is imbedded in the crop being grown. It's not the same as food fortification, which is increasing the nutritional value of food crops during the processing step.Rather of adding nutrients to plant foods during processing, bio-fortification makes food more nutritious as it grows. It's a practical and cost-effective way to get micronutrients to those who don't have access to diverse diets or other micro nutrient therapies. Howdy Bouis, an American economist, came up with the notion of breeding naturally high-in-micronutrient seed variants with high-yielding kinds, a concept that became known as bio-fortification. In 2016, he received the World Food Prize for his efforts to combat hidden hunger.

Methods of bio-fortification:



Agronomic bio-fortification:

Minerals are given to the soil to help the plants absorb the necessary micronutrients. Agronomic approach is a fertilizer-based method of applying micronutrients to the soil or foliar application, either alone or in conjunction with other fertilisers. It entails the application of required nutrient fertiliser for enrichment purposes, which is occasionally aided by other organic and inorganic additions. Through fertilisers, agronomic bio-fortification can provide transient micro-nutrient increases. In India, for example, foliar application of zinc fertiliser can raise grain zinc concentration by up to 20 ppm in wheat grain.

Conventional bio-fortification:

Food crops are conventionally bred for desirable characteristics through controlled breeding of agricultural plants to increase their ability to absorb and retain nutrients. This strategy necessitates the crossbreeding of crops with naturally high nutritional content with high-yielding cultivars. It aids in the identification of crops with high concentrations of desired nutrients. After that, they're crossed with other traits from targeted regions like high yielding, viral resistance, and so on. Parent lines with high vitamin or mineral levels are crossed over several generations in traditional plant breeding to create plants with the required nutritional and agronomic features.

Genetic engineering:

It is the insertion of desired traits into plant germplasm by gene modification. It is a plant breeding-based method. It entails changing a crop's genetic makeup by introducing foreign genes

from a wild crop of the same species or another species that code for greater production of specific nutrients or disease resistance, which could make the host crop more nutrient-dense and improve its quality. When a nutrient does not occur naturally in a crop (for example, pro vitamin A in rice) or when sufficient concentrations of bio-available micronutrients cannot be properly bred into the crop, this method is advantageous. This entails inserting DNA into an organism's genome to introduce new or different features, like as disease resistance.

Benefits of Bio-fortification:

In India, the Green Revolution and similar movements were aimed at putting an end to famine. The country's food grain output has increased as a result of the Green Revolution, and it is now largely self-sufficient. The government has implemented a number of programmes and steps to guarantee that the environment is protected. In terms of calorific value, the population consumes enough food. Despite having 'enough to eat,' many people are not obtaining enough nutrients from their meals. As a result, there is a problem known as "hidden hunger." As a result, after the one-time investment to develop seeds that fortify themselves, bio-fortification capitalises on the regular daily intake of a consistent and large amount of food staples by all family members, recurrent costs are low once in place, and the bio-fortified crop system is highly sustainable. Bio-fortification is a viable method of reaching undernourished communities in rural locations that are relatively remote.

Conclusion:

Bio-fortification is a low-cost way to improve one's nutritional state. Bio-fortification strategies have enormous potential for combating malnutrition.

Bio-fortification with increased nutrient content, such as zinc, iron, selenium, and pro-vitamin A, will offer adequate quantities of minerals that are frequently deficient. International and national initiatives (such as the Harvest Plus programme) serve as pillars. It is possible to increase the quantity and bio-availability of key mineral elements in human meals, for example, in staple grains such as maize and wheat. Coordination and collaboration between nutrition experts, plant breeders, molecular biologists, and genetic engineers are required to achieve this.

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BIOPESTICIDES: NEED FOR TODAY'S AGRICULTURE

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Abstract

Competition, predation, and parasitism all occur in the natural world. It has been discovered that living creatures may be used in agriculture to protect crops against insect pests, fungal and viral diseases as well as nematodes, weeds, and molluscs, all of which pose a threat to the health of the crops. Many commercially available biopesticide products (which include active agents like as nematodes, bacteria, protozoa, fungi, parasites, viruses, and beneficial insects) are increasingly being used to manage a wide variety of pest species. An insecticide containing *Bacillus thuringiensis* represents over 90% of all biopesticide sales. Agrochemical sales are stagnant or even declining throughout the globe, whereas biopesticide sales are expanding at a rate of 10-25 percent each year. Biopesticides are targeted and leave no toxic residues. Agriculture pests may be eradicated with the help of these biological creatures. Crop productivity and environmental balance may both be improved by using these bio-inputs properly.

Introduction

There is a rising market for biological pesticides, which are displacing conventional pesticides in terms of market share. Biopesticides, along with genetically modified crops (GM crops), are a burgeoning and evolving sector that relies on biotechnological advances. In some cases, it is also observed that biopesticides and GM crops both complement and contend with each other. Organic farming and integrated pest management system together are the magnificent forces for increasing, biopesticides' market share. These are a popular alternative to traditional chemical pesticides among organic farmers, who prefer their "green" qualities of the crop. So as to enhance the efficacy in pest control system, it should employ both conventional methods and biopesticides. Biopesticides are defined as living entities that may include plants, bacteria, nematodes, fungus and viruses or the products obtained from these mentioned organisms that can be deployed to control pest populations. The major benefits of biopesticides are- less hazardous impact on environment and perhaps reduced danger to public health. They may also give more targeted intervention against certain pests, hence decreasing hazards to non-target insect pests. Moreover, pests are abundantly prone to acquire resistance to biopesticides than against conventional pesticides. And from the other side, conventional pesticides may deliver significant action much more immediately, while biopesticides may need time following application to take action. Integrated pest control systems may limit the need of the chemical

pesticides, reducing or at least neutralising the negative aspects related with either chemicals or biopesticides, while drawing the strengths of both.

Products

Biopesticides are usually applied in liquid or water-dispersible formulations, water-soluble pellets or powders. The ease of administration, the preferences of the farmers, and also the kind of dispensing equipment feasible all influence formulations. The majority of the market is dominated by liquid-based formulations (around 60%), followed by granules and lastly powder.

- ✓ **Bacterial**

a. *Bacillus thuringiensis* (Bt)

Many lepidopteran pests, such as *Heliothis sp.* and *Earias sp.* as well as *Spodoptera* and *Plutella,* are known to be susceptible to Bt. Numerous commercial crops employ Bt, namely rice, castor, cotton, cauliflower, tomato and cabbage. When Bt is ingested by the insect larvae, releases an endotoxin which binds to the intestinal lining of the midgut and creates pores and ultimately causes anion imbalance and paralysis. It culminates insect mortality in few days. About 500 and 600 different *B. thuringiensis* strains have been discovered. Bt have been found effective against 525 insects of diverse families. Several crops have been resistant to lepidopteran pests (skippers, moths and butterflies), as well as coleopteran pests (weevils, beetles) after the introduction of *B. thuringiensis*. Non-target insects are less likely to be killed by Bt-based insecticides than by chemical pesticides.

- ✓ **Viral**

a. Nucleopolyhedrosis virus (NPV)

NPV being a baculovirus infests variety of lepidopteran insect pests of tomato, cotton, maize, sunflower, vegetable crops, chickpea, groundnut, sorghum etc. Internally, infectious virus particles begin to wreak havoc on the insect when it ingests the virus and develops inside the nuclei of the host cell. NPV targets specific pests and harmless to non-target insect pests. Hence, it is possible to utilise them in integrated pest management strategy to enhance the effectiveness of other biocontrol agents. Nearly 300 isolates of NPV have already been reported in Diptera (5%), Hymenoptera (6%) and Lepidoptera (88%).

b. Granulosis virus (GV)

Approximately 65 granulosis virus isolates have been documented solely in Lepidoptera. GVs are often more host specific than NPVs being transmitted by egg or orally. It is possible for the virus particles to survive for years under ideal circumstances, owing to their protein barriers. After larvae are infected with GVs, the protein coat dissolves inside the insect gut, allowing the viral DNA to enter digestive cells and begin infecting them. As a result of its inability to digest, the insect begins to deteriorate and die.

- ✓ **Fungal**

a. Beauveria bassiana

Biocontrol of foliar feeding pests has been the primary focus of *B. bassiana*. It causes a disease known as white muscadine. When *B. bassiana* spores are in proximity to an insect's cuticle, they germinate and begin to develop within the host's body. It creates poison and depletes nutrition from the insect as it spreads throughout its body, eventually killing it. Fungal pathogens, in contrast to bacterial and viral insect pathogens, do not require to be captivated by the hosts to

infect them. Fungi return to their original form as white mould after the host has died, generating millions of new spores. *Beauveria* spores kill aphids in 3 to 5 days at a temperature of 22.22 °C, but the pace depends on the temperature. Whiteflies, aphids, thrips, psyllids, weevils, and mealybugs are among the pests against which *Beauveria bassiana* is used.

- ✓ **Predators, Nematodes, Parasitoids**

a. Green Lacewings

Crop fields are teeming with *Chrysopa carnea* and *Chrysopa rufilabris*. Eggs laid by lacewings hatch within a few days. Larva feeds on immature whiteflies, mites, aphids, tiny worms, and thrips. In around 5 days, the larvae of the lacewings hatch, and the cycle is repeated. A feeding supply and rice hulls are often added to lacewing eggs for sale.

b. Lady Bird Beetles

They are one of the most conspicuous and well known benign predatory insects. It lays eggs, and within 7 days, they develop into small larvae. After three to four weeks, larvae reaches the pupae stage, and then within a week, young adults comes out ready to prey upon insects. Ladybug feeds on small worms, aphids, and also on varied range of insect eggs.

c. Pirate Bugs

Orius being a common predator, feeds upon thrips, mites, small caterpillars and aphids. Approximately three weeks are required to complete the whole life cycle. Within four to five days of being deposited, the eggs hatch. *Orius* kills its host by puncturing and withdrawing the body fluids till death.

d. Syrphid Flies

It is also known as Flower fly and hover fly. In its larval stage they prey upon small and soft-bodied insects. Early in the growing season, when temperatures are colder and other predators are less effective, they have been useful in managing aphid infestations.

e. *Trichogramma* parasitoid

They are small wasps that are exclusively egg parasites. Various lepidopteran pests (moths, butterflies, etc.) eggs are used for the egg laying of *Trichogramma*. *Trichogramma* larvae prey upon and kill the host egg after hatching, preventing the host population from multiplying. For more than 200 insect species, *Trichogramma* has been shown to be an efficient egg parasitoid. Paddy, sugarcane, vegetable, cotton, and fruit pests are the targets for this biocontrol agent. *Trichogramma* has a significant benefit over other pesticides since it is an egg parasite. It phase out pests much prior they are capable of causing damage to the crop.

f. *Heterorhabditis bacteriophora*

H. bacteriophora, an entomopathogenic nematode, is used to manage the coleopteran pests (beetle larvae) in the soil. *Heterorhabditis* can effectively move through soil in search of a host. Then nematode discharge a symbiotic harmful bacterium (Photorhabdus) after effective active penetration inside the larval body via the cuticle, which multiplies quickly and voraciously kills their host within 24 to 72 hours. New hosts are searched by newly hatched juvenile nematodes. Using *H. bacteriophora*, which is mostly deployed to combat root weevils, could help horticulture and decorative crops a lot.

Conclusion

For biocontrol agents, organic farming is an important market. The future of the biopesticide industry is dependent on a number of things. Biopesticides are finding a large and robust market in organic farming. Because of the success of Bt-based products, biopesticides are now widely used in agriculture as an alternative to traditional insecticides, nematicides, and fungicides. Also, integrated pest management includes the use of biopesticides in addition to crop rotation, cultural treatments, etc.

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BRINGING FOREST TO CITIES: BENEFITS OF URBAN FORESTRY

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Abstract
Urban forestry is an innovative approach of integrating forest-like ecosystem into urban environments, aiming to enhance the quality of life in rapidly growing cities. This discipline focuses on the strategic planning, management, and expansion of tree cover and green spaces within urban settings. By introducing and maintaining forest elements in cities, urban forestry provides a range of ecosystem services including air quality improvement, climate regulation, and urban heat island mitigation. It also fosters biodiversity, provides recreational opportunities, and enhances aesthetics and psychological well-being of the residents. The implementation of urban forestry involves collaboration between municipal authorities, environmental organizations, and local communities. The urban forests projects of many cities highlight its benefit in reducing carbon footprints, managing stormwater, and creating sustainable urban habitats. As urban areas continue to expand, the principles of urban forestry offer a pathway to create more resilient, liveable, and ecologically balanced cities.

Keywords : Biodiversity, Carbon footprints, Climate resilience, Habitat, Tree cover

Introduction

Urbanization is a defining characteristic of modern society, with more than half of the world's population now residing in urban areas **(James, 2024).** As cities expand, they often do so at the expense of natural landscapes, resulting in a loss of biodiversity and green spaces. This trend has significant implications for environmental sustainability and the quality of life of urban residents. Urban forestry, the management and care of tree populations in urban settings, presents a viable solution to mitigate these negative impacts.

Urban forestry encompasses the planning, planting, and maintenance of trees and green spaces within cities. It aims to create a harmonious relationship between urban development and nature, providing a range of ecological, social, and economic benefits. These green spaces play a crucial role in enhancing the liveability of cities. It contributes to environmental sustainability, public health, and social well-being **(Salleh *et al*., 2024)**. The trees and green spaces act as natural air filters, reducing air pollution by trapping dust, pollen, and smoke particles. They also sequester carbon dioxide and reduces greenhouse gas emissions mitigating the effects of climate change **(Raj *etal*., 2023)**. Furthermore, urban forests regulate temperature by providing shade and

releasing moisture through transpiration, thereby reducing the urban heat island effect **(Cheela*et al*., 2021).**

Access to green spaces due to urban forestry has been linked to improved mental health, reduced stress levels, and increased physical activity. It provides space for social interaction and community events, fostering a sense of belonging and strengthening social ties among residents **(Clarke *et al*., 2023)**. They also offer recreational opportunities such as hiking, picnicking, and bird-watching, contributing to the tourism industry **(Seremet *et al*., 2023)**. Moreover, these urban forests serve as habitats for various species of birds, insects, and small mammals, promoting biodiversity within urban settings. They also act as ecological corridors, facilitating the movement of wildlife and maintaining genetic diversity. The urban green spaces can enhance property values, attract tourists, and stimulate local economies. Also, if trees are planted strategically in urban setting, it provides shade and windbreaks, reducing the need for air conditioning in the summer and heating in the winter. This leads to significant energy savings for urban dwellers **(Li *et al*., 2024)**. In addition, trees absorb pollutants such as nitrogen dioxide, sulfur dioxide, and carbon monoxide, improving air quality and reducing respiratory problems among urban residents **(Ramon *et al*., 2023)**.

Urban forests and parks attract tourists and visitors, boosting local economies. The urban forests are increasingly recognized for their role in creating more sustainable and resilient cities. For instance, in India, different city projects like Mumbai's “Urban Forest” Projects, Delhi's “Green Delhi” Initiative, Bangalore’s Green Programme, Hyderabad's popular “KBR National Park” and “NTR Gardens” projects and Chennai's “Tree Planting Campaigns” highlight their commitment to increase green cover, combat air pollution and create more pleasant living environments. These initiatives are mainly done to reintroduce and expand forest areas within and around the city. These projects integrate green spaces into urban planning and provide residents with recreational areas while supporting local wildlife.

Fig. 1 Benefits of Urban Forestry

Challenges in Urban Forestry

Despite its numerous benefits, urban forestry faces several challenges that need to be addressed for successful implementation:

1. **Limited Space**: Urban areas often have limited space for planting and maintaining trees. Competing land uses, such as infrastructure development and housing, can restrict the availability of green spaces.
2. **Funding and Resources**: Establishing and maintaining urban forests require substantial financial investments and resources. Securing funding for tree planting, maintenance, and management can be challenging, particularly for cities with constrained budgets.
3. **Public Awareness and Participation**: Effective urban forestry relies on public awareness and community involvement. Engaging residents in tree planting and care initiatives is crucial for the success of urban forestry programs. However, lack of awareness and participation can hinder these efforts.
4. **Environmental Stress**: Urban trees are exposed to various environmental stress, such as pollution, soil compaction, and limited water availability. These factors can negatively impact tree health and longevity, necessitating careful species selection and management practices.
5. **Policy and Planning**: Integrating urban forestry into city planning and policy frameworks is essential for its success. However, inadequate planning and lack of coordination among stakeholders can pose significant challenges to the implementation of urban forestry initiatives.

Strategies for Successful Urban Forestry

To overcome the challenges and maximize the benefits of urban forestry developing a comprehensive urban forestry plan that integrate tree planting and maintenance into city planning processes is crucial. These plans should consider implementing sustainable urban forestry practices, such as proper tree selection, suitable site selection, soil management practices and irrigation techniques, that can enhance tree health and longevity. Also engaging the community in urban forestry initiatives is vital for their success. Public awareness campaigns, tree planting events, and educational programs can encourage residents to participate in tree care and maintenance. However, fund security from various sources, such as government grants, private sector investments, and non-profit organizations, can support urban forestry projects to a greater extent. Establishing partnerships with local businesses, community groups, and environmental organizations can also provide valuable resources and expertise. Integration of urban forestry into city policies and regulations can provide a supportive framework for its implementation. Establishing tree protection ordinances, incentivizing green infrastructure, and incorporating urban forestry into land-use planning can promote its integration into urban development.

Conclusion

Urban forestry offers a promising solution to the challenges posed by rapid urbanization and the loss of natural green spaces. By bringing forests to cities, urban forestry enhances environmental sustainability, public health, and overall urban well-being. Despite the challenges it faces, strategic planning, community engagement, funding, sustainable practices, and policy integration can pave the way for successful urban forestry initiatives. As cities continue to grow, embracing urban forestry will be essential in creating greener, healthier, and more liveable urban environments.

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IMPORTANT DISEASES OF JUTE IN NORTH EASTERN REGION OF WEST BENGAL AND ITS INTEGRATED MANAGEMENT

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Abstract
Jute serves as a superior substitute for synthetic fibers, which have already harmed both living and non-living organisms. Jute, a naturally biodegradable, pollution-free fibre, has numerous roles in a variety of applications. Tropical and Southeast Asian countries, particularly the eastern parts of India and Bangladesh, cultivate this crop, which thrives in a warm, humid climate with ample amounts of intermittent rainfall. Fungi, bacteria, viruses, and other factors cause biotic constraints in production. The incidence of different diseases is one of the limiting factors in productivity improvement. Climate change can lead to changes in the intensity of jute diseases, the development of new strains, and the implementation of management strategies. This paper will give the details of the diseases prevailing in the North Eastern Gangetic Plains of West Bengal State, which were the main factors in the reduction in yield.

Key words: Jute, stem rot, wilt, anthracnose,integrated disease management

Introduction

The use of synthetic products resulted in an increased level of pollution, affecting both the environment and living organisms. Therefore, from a sustainability perspective, we urgently need to replace environmentally harmful synthetic materials with natural, renewable, and biodegradable materials. Eastern parts of India predominantly cultivate Golden Fibre (Jute, *Corchorusolitorius* L., and *C. capsularis* L.). Pre-kharif saw the cultivation of this crop primarily in West Bengal, Assam, and Bihar. Jute, one of the natural fibres, plays a vital role in developing composite materials that show potential in a variety of applications, such as household, automotive, and medical appliances. Synthetic fibers have significantly reduced the area, even though the entire region is under cultivation due to high rainfall. Diseases affecting jute played a significant role in reducing yield and compromising the quality of the fiber. India encounters losses of approximately 11-18% due to diseases.

The most important jute disease is stem rot, caused by *Macrophominaphaseolina*. Other diseases are Anthracnose (*Colletotrichumcorchorum* and *C. gloeosporioides*), Black Band (*Botryodiplodiatheobromae*), Soft Rot (*Sclerotiumrolfsii*), Hooghly Wilt (*Ralstoniasolanacearum*, *Meloidogyne incognita*, *Rhizoctoniabataticola*, and *Fusarium* complex), and Jute Mosaic (Begomovirus).

1. Stem rot:
This occurs in all the stages of crop

A. On young seedlings:
Dark, thin lesion on the collar region and also on the cotyledons, under high humid condition, lesions enlarge up and down wards killing the seedling. This pathogen spread rapidly, often called as damping off. Damping off is seen only in young seedlings but seedling blight may occur in young as well as older seedlings up to 6-8" height.

B. On grown up plants:
All the varieties of both *C. olitorius* and *C.capsularis* are more or less susceptible to the disease. In mature plants also innumerable minute dots, brown in colour appear on lamina and the margin of the leaves. But soon after the entire leaf blade, mid ribs and petioles are completely involved. Infection proceeds to the stem through the petiole or directly from lamina if the infected leaves hang down and touch the stem. The stem develops brown to black necrotic spots which vary in size and shape. Heavily infected stem of susceptible variety often breaks at the lesion site while comparatively less affected ones remain standing in the field showing shredded fibre tissue at the lesion. Lesion spread along the stem causing bark shredding. Affected plants show wilting and premature defoliation. Disease spreads from basal stem to root, killing the plant. Pycnidia formed on the infected root and stem.

C. On inflorescence:
Capsules and seeds were noticed with black discolouration and small sclerotia found on the infected capsules. The pathogen disseminated by seed, soil and air.

D. On root of the plant:
Young rootlets or branch roots or even the main roots are marked by light brown areas. The plants show wilting symptoms from the top. Stem colour fades gradually from light to dark brown and finally the stem withers completely and shrivels into a dry hard stick. Affected plants if uprooted show rusty brown rotted roots.

Pathogen:
The causal organism is *Macrophominaphaseolina* (Tassi). Goid is a dreaded pathogen that can infect more than 500 plant species in approximately 72 families. The pycnidial stage is *M. phaseolina*, while the sclerotial stage is *Rhizoctoniabataticola* (Taub.). The disease is caused by the pycnidial and sclerotial stages, while the perfect stage, *Orbiliaobscura*, is very rare. It is highly variable, with isolates differing in micro-sclerotial size and the presence or absence of pycnidia.

Host range:
Potato, cotton, legumes, tobacco, sesamum, mulberry, eggplant. Survives all the year round. Potassium deficiency in the soil been found to increase the incidence of stem rot. According to De (2013), soils with a low pH (5.6–6.5), a high level of nitrogen, high rainfall, and high humidity favour the infection of *M. phaseolina*. March sown crops suffer more than late sown crops do. Older plants are predisposed to higher soil temperatures and low soil moisture.

2. Anthracnose:
In seedling stage it appears on leaf and stem as brownish spot and streaks following drying up of the entire stem. On matured plants at first light yellowish patches can be seen on the stem. These

turns to yellowish brown water soaked lesions on the stem, a depressed spot which soon develops into characteristic irregular spots. Spot turn dark brown and finally turns black. Several spots coalesce- forms large patches, girdling of stem causing deep necrosis showing cracks on the stem and exposing the fibre tissues. Fibres extracted from such affected plants are speky and knotty and fall under very low grade. In severe infection, the plant will wilt immediately or under moderate infection the plant survive and produce pods. Dark brown to black necrotic lesion were produced on the pods in case of seed crop. Infected seeds are lighter in colour, shrunken and germination is poor. In *C.olitorius* incidence occurs at the later stage of crop growth, brown to black spots appear on the stem but the damage is not much.

Pathogen:
In *Capsularis* jute it is caused by *Colletotrichumcorchorum* and *Olitorius* jute by *C. gloeosporioides.* The fungus invades the vascular bundles, weakening the fibre bundles. Rapid spread and severe damage noticed during hot humid condition at the months of months of July- August. Acervuli are produced on the spots under high humidity.

3. Black band disease:
Small blackish brown lesion which gradually enlarge and encircle the stem resulting in withering of epical and side branches. Stems infected at the lower portion often break at that point. The affected plants loose leaves, turns brown to black and remain standing as dry sticks. Innumerable, erumpent pycnidia, which extrude masses of spores, are produced. On rubbing the stem surface, unlike stem rot profuse black shooty mass of spores adhere to the fingers. Crops raised from infected seeds show seedling blight symptoms also.

Pathogen : *Botryodiplodiatheobromae (Syn.Diplodiacorchori)*
The pathogen is seed and air borne in nature, has wide host range. The disease incidence was increasing now days. Cause serious damage to the older crop from July onwards, from which neither fibre nor seeds can be obtained.

4. Soft Rot:
Earlier it was a minor disease but gaining importance fast. Soft, brown wet patch appears on the stem base. Skin peels off and exposed fibre layers turn rusty brown and plants wilt. White cottony mycelia growths are seen at the site of infection. Stem breaks from the point of infection and at the later stage globose to subglobose mustard seed like sclerotia are produced which fall on the ground and overwinter to infect next susceptible crops.

Pathogen : *Sclerotiumrolfsii*
Fungus first grows on the litter of fallen jute leaves, from there it infects the stem base. The pathogen attack begins when the crop is 80–90 days old. When the weather is hot and the soil is wet, pathogen grows and initiates infection in the collar region. Soft rot decreases if fallen leaves are destroyed quickly from plant base.

5. Hooghly wilt:
Drooping and wilting of leaves starting from the base and go upwards. Later, all the leaves of the infected plants defoliate leaving the stem to stand naked and such plant may the diagnosed even from a distance. Affected stems are soft with slimy fluid comes out on slight pressing.

Pathogen:
A complex disease involving *Ralstoniasolanacearum* (*Pseudomonas solanacearum*) *Rhizoctoniabataticola*, *Meloidogyne incognita* and *Fusariumsolani*. *Rhizoctoniabataticola* and

Meloidogyne incognita facilitate the entry of the bacteria. This disease is most prevalent in the areas where jute is followed by potato or other solanaceaous crops.

6. Mosaic:

Different jute-growing belts in India and Bangladesh reported the disease in capsularis jute. In India, researchers reported the disease in *Capsularis* jute from West Bengal (Roy *et al.,* 2006; Ghosh *et al.,* 2007) and Assam. Recently, the incidence of the disease has increased from 20 to 40 percent (Ghosh *et al.,* 2007).

The initial stage of the disease is characterized by the appearance of small yellow flecks on the leaf lamina, which gradually increase and intermingle with green patches, producing a yellow mosaic appearance. Leaves, in some cases, produce small enlargements along the midvein. In extreme cases, the infected plant experiences stunting, leading to a 20% reduction in plant height. The incidence was about 50% on some leading cultivars, such as JRC 7447 and JRC 212 (Ghosh *et al.,* 2007).

Pathogen:

Based on symptomatology and transmission, the jute mosaic virus was found to be a member of the Begomovirus under family Geminiviridae. Reports indicate that the white fly (*Bemisiatabaci*) transmits the causal virus. Some workers also reported the transmission of the virus through seeds. The virus is graft transmissible and also carried through seed

Integrated Disease management

1. **Selection of species / varieties**
    a) Responses of different varieties to various diseases are different depending upon the area and the type of the pathogen in that locality.
    b) Stem rot around Coochbehar and Katihar areas affects JRO 632 less than JRO 524.
    c) In capsularis, anthracnose is a major disease, but in *C. olitorius*, it is practically negligible.
    d) In traditional *C. capsularis* belts, growers may cultivate *C. olitorius* varieties wherever possible.
2. **Clean cultivation**
    a) Most of the jute pathogens are seed-borne, soil-borne, and air-borne.
    b) Once introduced into the soil, the pathogens can remain in the debris, stubbles of last-year crops, and weeds for a long time.
    c) Collect and burn the waste, and ensure the land is clean.
    d) Deep ploughing and prolonged exposure of the soil to the sun reduce soft rot infection.
3. **Adjustment of soil pH**
    a) The diseases are more commonly found in acidic soil with a pH value of 5.5 to 6.0.
    b) Depending on the pH of the soil, apply liming at a rate of 2 to 4 tonnes/ha.
    c) A neutral soil with a pH between 6.5 and 7.5 is preferable.
    d) Indiscriminate fertilizer use, particularly nitrogenous fertilizers, makes the soil acidic.
    e) For lime application, care should be taken so that the application is done at least a month before the sowing; otherwise, the seedlings may be damaged.
4. **Use of clean and healthy seed:**
    a) Infected seeds serve as the primary source of inoculum.

b) Even 1% seed infection produces 1500 infection loci per ha, and this might multiply by many folds during the crop growth phase.
c) Use clean and healthy seeds.
d) Apply the recommended fungicides to the seeds.
e) Carbendazim, Tebuconazole at 2 g/kg of seed, or Dithane M 45 at 5 g/kg of seed are effective in checking the seed-borne infection.
f) Effective, preferably local, isolates of *Trichoderma* spp. (*T. harzianum, T. viride,* and *G. virens*) can also treat seeds at a rate of 10 g/kg of seed.

5. Adjustment of sowing time:
a) The sowing time was slightly adjusted.
b) Sowing time again depends on the preceding and succeeding crops.
c) Jute sown after the second week of April is less susceptible to stem rot and root rot.

6. Seed treatment:
a) Bavistin @ 2 g / Kg. of seed or Dithane M 45 @ 5 g / Kg. of seed and *Trichoderma* spp. (*T.harzianum*/ *T. viride/ G. virens*) @ 10g/kg of seed are effective in checking the seed borne infection.

7. Balanced fertilizer:
a) Excess nitrogen makes the plants more susceptible to diseases, while potash confers some degree of resistance.
b) There is a general tendency to add more nitrogenous fertilizers for quick vegetative growth, but this approach invites more disease at the later stage.
c) Deficiencies in some micronutrients like Mg, Zn, and B may also aggravate the infection of the *Macrophomina* disease complex in jute.
d) Use balanced fertilizers judiciously, depending on the condition of the soil.

8. Proper spacing:
a) If the population is too thick disease attack is more
b) Close spacing is very much conducive to stem rot infection
c) In line sown crop 30 cm row to row and 5-6 cm plant to plant spacing gives good result
d) Spacing can be maintained at the time of thinning

9. Timely weeding and thinning:
a) *Macrophominaphaseolina, Ralstoniasolanacearum*, and *Sclerotiumrolfsii* have a very wide host range, which includes a good number of weeds.
b) These weed pathogens serve as a source of inoculum for the jute crop.
c) Timely weeding should be done.
d) Chemical weed control is very effective.
e) Apply a pre-emergence dose of 0.75 kg a.i./ha one day after sowing.
f) Post-emergence application of quizalofop ethyl (Targa super) @ 1.5 ml +1 ml adjuvant per litre of water
g) Mulching with available agricultural waste or intercropping with red *Amaranthus*sp. effectively reduces the weed population.

10. Proper drainage:
a) Jute, particularly the *C.olitorius* variety, does not tolerate waterlogging
b) Some of the varieties can withstand inundated conditions for some time.

c) However, they grow many adventitious roots in the basal region, where they either produce no fiber or, if they do, the quality is very low.

11. Crop rotation:

a) *Macrophominaphaseolina* targets plants such as brinjal, cowpeas, peas, ground nuts, and black gram.
b) *Sclerotiumrolfsii* attacks plants other than jute, such as sesamum, groundnut, and brinjal.
c) The root knot jute nematode causes the same disease in brinjal and tomato.
d) Hoogly wilt, a jute pathogen, is also a major pathogen in potatoes and other solanaceous vegetables such as brinjal, tomato, and so on.
e) The coexistence of *Ralstonia*, *Meloidogyne*, and *M.Phaseolina* exacerbates Hoogly wilt.
f) The inclusion of paddy always reduces the disease in jute.
g) Use of solanaceous vegetables such as potato, brinjal, and tomato over time increases wilt in *C. olitorius* jute.
h) Some important rotation are:-
   Jute - Paddy - Paddy
   Jute - Paddy - Wheat
   Jute - Paddy - winter vegetables (other than *solanaceaous* ones)
   Jute – Paddy - Potato (or other *solanaceaous* vegetables if these are the major crops of the area but these should be replaced by paddy or wheat after two years).

12. Need based application of chemicals:

a) Carbendazim at 2 g/liter of water, Blitox-50 at 5 g/liter of water, or Dithane M 45 at 3 g/liter of water provide excellent control.
b) If the infection is very high in stem rot, alternate sprays of Blitox-50, then Carbendazim, and then again Blitox-50 (total of three sprays) provides good control.
c) When it comes to seedling blight and damping symptoms at the very early stage of the crop, one spray of Blitox-50 or Bavistin provides good protection.
d) Applications of Carbendazim, Benomyl, Rovral, or Thiram at 0.2% are effective for controlling root rot.
e) At the initial stage of infection, spraying Copper oxychloride at 0.75% is helpful in reducing the incidence of *Colletotrichum*sp.
f) Direct the spraying of Blitox-50 towards the ground level in cases of soft rot.
g) Control the vector (white fly- *Bemisiatabaci*) to keep the jute mosaic in check. Spraying of Metasystox at 1.5 ml/litre of water or Imidachloprid at 1.5 ml/litre of water.

13. Biological control measures:

Organic soil amendment

a) Applying neem cake amelioration at a rate of 15-20q/ha to the soil significantly reduces *Macrophomina* infection. *Azadirachtin*, acting as a chitin inhibitor of the fungal spore cell wall and containing 15-25% chitin, can lyse the cell wall of fungal propagules in neem cake amended soil, potentially stimulating the fungal antagonist in the soil.

b) Beneficial microbes such as *Bacillus, Clostridium, Rhizobium, Azotobactor*, and a fluorescent *Pseudomonas* species typically dominate neem cake amended soil, alongside an antagonistic fungal population that includes *Trichoderma, Aspergillus niger, A. flavus, Penicillium rubrum, P. chrysogenum, Gliocladium*spp., and *Actinomycetes*.
c) Soil amendment with mustard or sesamum oil cake at 20q/ha is effective in controlling root rot.
d) Soil amelioration with turmeric dust, mustard or groundnut cakes, and sawdust has been found effective in reducing the population of *Ralstoniasolanacearum*.
e) Mahua, groundnut oil cakes, and sawdust at 12–15 q/ha have been found beneficial in reducing the nematode population.

Bio-fertilizer microorganisms

a) Bacterial biofertilizer *Azotobacter chrococcum, Azospirillum brassilense,* and *Rhizobium* are all bacteria that help plants and soil fix nitrogen through mutually beneficial or commensal relationships.
b) *Pseudomonas striata* and Vesicular Arbuscular Mycorrhiza (VAM) solubilize P for potential host growth.
c) Upon field application, VAM fungi mobilize P available to the host plant in an obligate symbiotic association.
d) Some fluorescent pseudomonads release siderophore and chelate iron, making them unsuitable for pathogens.
e) *Rhizobium japonicum* produces rhizobiotoxins and combats *M.phaseolina* infection.
f) These organisms suppress the jute root rot pathogen in various ways, such as by acting as a physical barrier in an altered eco-system, strengthening the host through improved nutrition, parasitizing fungal hyphae, or releasing fungitoxic antibiotic compounds (Ramasubramanian, *et al.,*2010)

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GENOMICS FOR CROP IMPROVEMENT

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Abstract
A revolutionary strategy in agriculture, genomics for crop enhancement makes use of cutting-edge genetic knowledge to boost crop resilience, yield, and nutritional content. The use of genomics in crop development is examined in this work, with a particular emphasis on identifying and modifying the major genetic features that determine yield, disease resistance, and environmental adaptability. By using methods like genome sequencing, marker-assisted selection, and gene editing, scientists may create improved crop types more quickly. Considerable progress has been made in tackling global issues like food security and climate change as a result of the combination of genomes with conventional breeding techniques. The ethical, financial, and legal factors that are crucial for the long-term implementation of genomic technology in agriculture are also covered in this paper.

Introduction
Genomics is the collaboration of molecular biology that mainly includes the structural, functional, evolutional, mapping and editing of genomes. Genome refers to a complete set of DNA present in an organism. It includes all of the genetic information required for almost all living things to be built and function. The main aim of genomics is to characterize and quantify all of an organism's genes, as well as their interactions and effects on the organism as a whole. By studying the whole genome, we can understand the mechanism of development of the biotic and abiotic stress in plants and also helps to decide the effective treatment for curing the biotic and abiotic stress.

Human genome project was one of the greatest achievements in the scientific history. It was launched in launched in October 1990 and completed in April 2003, the Human Genome Project's signature accomplishment – generating the first sequence of the human genome – provided fundamental information about the human genetic blueprint, which has since accelerated the study of human biology and improved the practice of medicine.

Following are the different types of genomics

1. Structural genomics
2. Functional genomics
3. Comparative genomics

Structural genomics
The structural genomics focuses on the sequencing and interpretation of genome content. The development of physical and genetic maps of a chromosome's is frequently one of the initial stages in genome characterization. These maps provide information on the relative positions of genes, molecular markers, and chromosome segments—information that is often essential for

aligning sequenced DNA segments into a whole-genome sequence and positioning chromosome segments.

Objectives of structural genomics

- Aims to determine structure of every protein encoded by the genome.
- Identify novel protein folds and 3-D structures for better understanding the functions of proteins.

Functional genomics

A genomic sequence is, by itself, of limited use. Without the ability to read, it would be similar to owning an extensive set of encyclopedias; you could identify the various letters but the text would be meaningless. In short, functional genomics involves searching genome sequences for meaning in order to find genes, recognize how they are arranged, and understanding their functions.

Objectives of functional genomics

- Aims to collect and use data from sequencing for describing gene and protein functions.
- Functions of genes and non-gene sequences in genomics.
- Gene and protein interactions.

Comparative genomics

The comprehensive data that genome-sequencing studies offer regarding the composition and arrangement of genes in various species—and even among distinct individuals within the same species—allows findings on the evolution of genomes and the operation of genes. They additionally provide crucial information regarding the relationships between organisms during evolution as well as the variables affecting the rate and course of evolution.

Objectives of comparative genomics

- Aims to compare genomic features between different species.
- It is for better understanding the evolutionary relationship.
- To determine the functions of each genome E.g. studying gene model organisms' yeast and human

Application of genomics in crop improvement:

1. **Marker-Assisted Selection (MAS):** MAS uses genetic markers (such as SNPs or SSRs) associated with specific traits to select plants with desired characteristics. Breeders can identify and track these markers during breeding programs, enabling faster and more precise selection. For example, in rice breeding, MAS has been used to select for disease resistance, grain quality, and yield-related traits.
2. **Hybrid Seed Production:** Genomics helps in developing hybrid seeds with improved vigor, yield, and disease resistance. By understanding the genetic basis of heterosis (hybrid vigor), breeders can create better hybrid combinations. Genomic tools allow the identification of parental lines with complementary traits, leading to successful hybrid seed production.
3. **Bio stimulants and Stress Tolerance:** Genomics aids in identifying genes related to stress tolerance (e.g., drought, salinity, heat). Researchers can develop bio stimulants that enhance plant growth and stress resistance by targeting specific genes or pathways. For instance, understanding the molecular mechanisms behind osmotic stress responses can lead to the development of effective bio stimulants.

4. **Genome Editing (CRISPR-Cas9):** CRISPR-Cas9 technology allows precise modification of specific genes. Researchers can edit genes responsible for disease susceptibility, nutrient uptake, and other agronomically important traits. Genome editing accelerates the development of improved crop varieties without introducing foreign DNA.
5. **QTL mapping:** QTLs are genomic regions associated with quantitative traits (traits influenced by multiple genes). QTL analysis aims to identify these regions using mapping populations, molecular markers, and statistical methods. Genetic markers (such as SSRs and SNPs) are used to track specific genomic regions.

Conclusion

Crop development strategies that incorporate genomics offer previously unheard-of prospects to improve agricultural sustainability and production. Scientists can create crops that are more tolerant of environmental stressors, resistant to pests and diseases, and able to produce larger yields by figuring out the genetic basis of desired features. The development of superior crop varieties is accelerated through the synergistic application of genomic techniques and conventional breeding practices, thereby contributing to environmental sustainability and global food security. Nevertheless, regulatory, commercial, and ethical issues must be carefully considered for genomic technology to be successfully applied in agriculture. In order to guarantee the long-term sustainability and adoption of genomics-based crop improvement, future research should concentrate on addressing these issues while carrying out innovative and effective genomic technique development.

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GEOINFORMATICS IN AGRICULTURE

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Agriculture drives economic growth and fulfills essential human needs for food and fiber. The Green Revolution (1960s-1980s) significantly boosted productivity and food security. With food demand projected to rise by over 70% by 2050 and limited arable land, agricultural intensification is necessary, involving increased use of fertilizers, pesticides, and water, which pose environmental challenges.

Precision agriculture (PA) addresses these issues using advanced technologies like remote sensing, GPS, GIS, IoT, Big Data, and AI. PA enhances crop production while reducing environmental impacts. Remote sensing systems, categorized by sensor platform and type, provide critical data. These systems enable high-resolution imaging for site-specific management, aiding crop health monitoring, biomass estimation, resource optimization, and pest mapping, promoting sustainable farming.

What is Geoinformatics?

Geoinformatics, also known as geographic information science (GIScience), is a multidisciplinary field that integrates geography, cartography, remote sensing, computer science, and information technology to collect, analyze, interpret, and visualize geographical and spatial data. This field emphasizes capturing, storing, managing, analyzing, and presenting spatial information in digital formats, enhancing our understanding of the Earth's surface and the interactions between different geographic features. As a versatile tool, geoinformatics finds applications across various domains, including agriculture, where it plays a pivotal role in optimizing farming practices and promoting sustainability.

Geoinformatics Used in Agriculture

Precision Agriculture : Used to collect data on various factors, such as soil type, crop yield, and pest infestation. This data can then be analyzed to identify areas of variability within a field. Once these areas have been identified, farmers can use GIS to develop customized management plans for each area.

Global Positioning System (GPS)

The Global Positioning System (GPS) has revolutionized spatial data acquisition, progressing from handheld devices with 10-meter accuracy to centimeter-level precision with Differential GPS (DGPS). GPS technology records precise in-field variability, facilitating continuous position determination and yielding detailed yield maps when coupled with yield monitors. Integration of satellite data enhances field management strategies for chemical application, cultivation, and harvesting.

GPS combined with Geographic Information Systems (GIS) supports real-time data collection and analysis, crucial for precision agriculture. Applications include farm planning, soil sampling, tractor guidance, crop scouting, variable rate applications, and yield mapping, advancing efficiency and effectiveness in modern agricultural practices.

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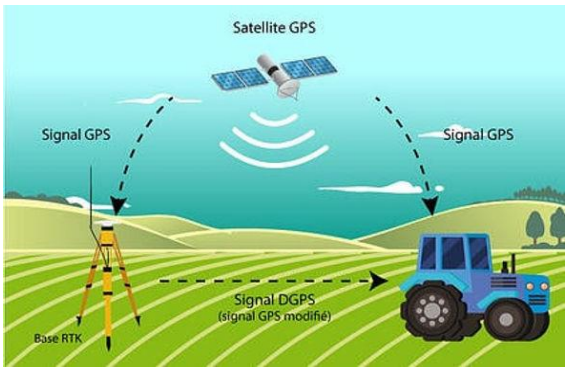
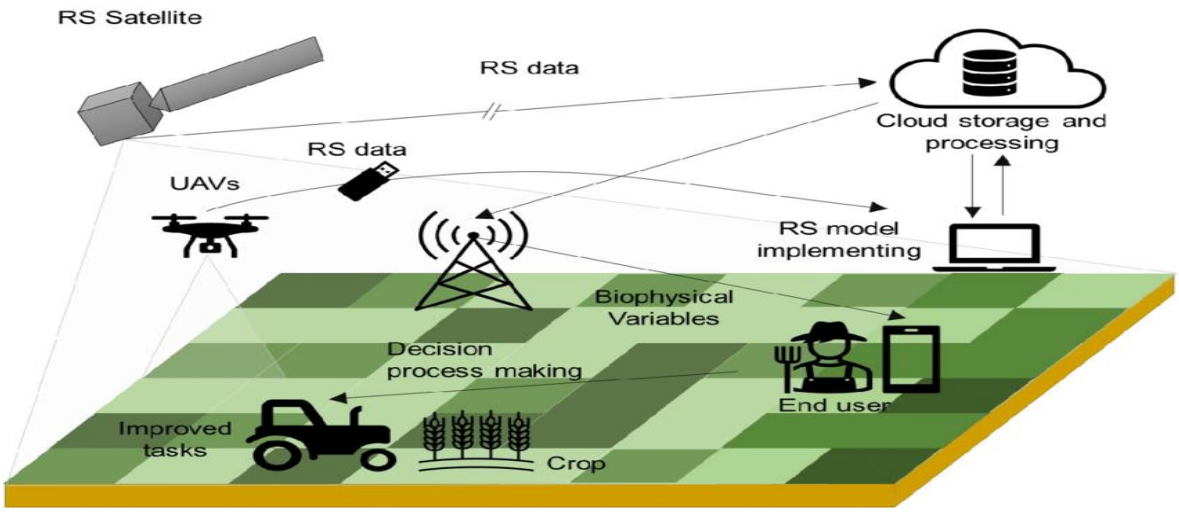
Geographical Information Systems (GIS) in Agriculture

A Geographic Information System (GIS) is a robust hardware-software database system designed for capturing, storing, retrieving, manipulating, analyzing, and displaying spatially referenced geographical data. It integrates cartography, statistical analysis, and database technology to create interactive maps that users can customize and navigate. GIS enhances farm management in agriculture by providing detailed environmental analysis and workflow visualization, optimizing crop yield estimates, soil amendment strategies, and erosion control. GIS integrates diverse map and satellite data sources to simulate natural systems, generating images and maps crucial for operational and strategic decisions. By combining GIS with models like EPIC, it further enables simulations to enhance regional crop productivity and agricultural management strategies.



REMOTE SENSING

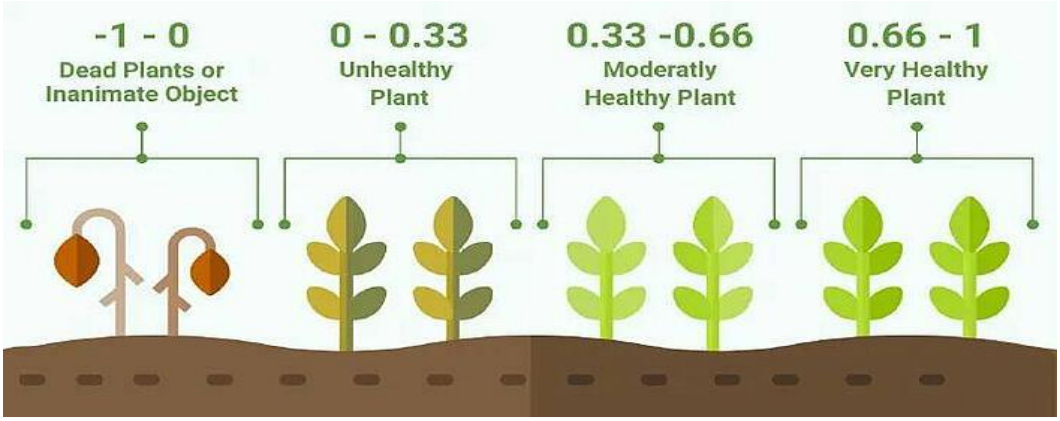
Remote sensing systems in agriculture vary by platform (satellite, aerial, ground-based) and type (passive, active). Satellites offer wide coverage but coarser resolution, while aerial platforms like UAVs provide finer detail (<5 m), ideal for precision agriculture (PA). Ground-based sensors, such as handheld or tractor-mounted devices, offer crucial detailed assessments. Sensors differ in spatial, spectral, radiometric, and temporal resolution. Hyperspectral sensors aid in vegetation analysis and disease detection, with recent advances in thermal infrared and microwave sensors for temperature and soil moisture assessment. Active sensors like synthetic aperture radar (SAR) provide high spatial resolution for site-specific management, enhancing crop health monitoring, biomass estimation, and pest mapping, promoting efficiency and sustainability in farming practices.



Variable Rate Technology (VRT) allows precise control of crop input application across fields. It includes controllers for granular, liquid, and gaseous fertilizers, operated manually or automatically via electronic maps. VRT adjusts inputs like tillage, fertilizer, weed and insect control, and irrigation based on field conditions. Components typically include a computer controller, GPS receiver, and GIS database. The controller varies application rates using GPS location data, maintaining accurate field maps of applied materials.

Vegetation Indices

Vegetation indices like NDVI, GNDVI, and SAVI use reflectance from different spectral bands to assess crop growth and vigor. NDVI measures red and near-infrared reflectance to indicate vegetation health but can be influenced by soil, atmosphere, and canopy conditions. Alternatives like SAVI, ARVI, and WDRVI adjust for soil brightness and atmospheric effects, offering more reliable assessments. Red-edge indices like RNDVI and NDRE excel in dense vegetation, providing better estimates of nutrient status and biomass. These indices enable precise monitoring of crop conditions, allowing farmers to optimize inputs like irrigation and fertilizers, enhancing productivity and sustainability.



Spatial Decision Support System (SDSS)

A Spatial Decision Support System (SDSS) integrates GIS, remote sensing, and GPS to assist in pest management, disease zones, irrigation, fertilization, and chemical use. Traditional DSS models like DSAT and InfoCrop simulate scenarios for optimal farm practices. Adding spatial data makes SDSS more intelligent, overlaying thematic datasets for agroecological zones and efficient simulation of high-yield scenarios. SDSS integrates crop modeling, database management, expert knowledge, and map-based outputs, aiding policy planners and farmers in making informed decisions.

Application of Geoinformatics in Precision Agriculture

Crop Growth stages:

The three technologies GIS, GPS and Remote Sensing above can be used to monitor the crop growth. The maturity period, crop stresses such as nutrient and water stress, disease, pest and weed infestation can be identified by using RS and GIS. Information gathered via different sensors and referenced using GPS can be integrated to create field management strategies for chemical application, cultivation and harvest.

Irrigation Water Management

Irrigation timing and rate are crucial for optimal crop growth and yield. Farmers base irrigation practices on water availability, infrastructure, laws, economics, farm size, and knowledge. Many

use uniform irrigation, while large farms use soil moisture monitoring for real-time data. Local agencies may offer irrigation advice based on weather conditions. Traditional methods often overlook field variability, but remote sensing can reveal it, enabling variable rate irrigation. This reduces water stress, promotes uniform yields, and minimizes water and nutrient loss. Remote sensing indicators like ET, soil moisture, and crop stress help accurately estimate crop water needs and schedule irrigation.

Soil Fertility, Micro and Macro Nutrients

GIS and remote sensing (RS) systems are layer-based, offering flexibility in overlaying various real-world data layers to optimize agricultural practices. Soil status mapping is a key component of ongoing national projects where soil samples are collected at the village level. National and state government mobile soil sampling units conduct soil tests and record sampling coordinates via GPS, creating a comprehensive state-level spatial inventory. Using these datasets, an interpolated surface for soil types can be generated, considering terrain, slope, and aspect in hilly regions. Once soil mapping is complete, it can be utilized to simulate crop yields with different varieties and agricultural inputs, enhancing precision farming practices.

Weed, Insect, and Disease Infestation

Mapping disease infestation hotspots are often reactive, addressing the issue after significant crop damage. However, integrating GIS and remote sensing (RS) provides a proactive solution. By mapping disease incidences, experts can analyze the underlying causes of crop infestations. These mapped areas can be spatially integrated with agroecological zones to simulate potential future hotspots for similar infestations. One major advantage of using GIS and RS is their ability to not only generate maps but also utilize analytical tools to simulate scenarios and provide farmers with an early warning system.

Climate and Crop Suitability

Recent advancements in remote sensing (RS) technology, particularly multispectral and hyperspectral sensors, yield high-resolution data capturing reflectance across visible, near-infrared, and mid-infrared spectra. This data aids in assessing crop health, cover, and soil moisture, crucial for operations like stress mapping and irrigation management. RS assesses nutrient content in wheat, rice, sorghum, and other crops, bolstered by geostatistics, image analysis, and AI. It informs policies on food security and sustainable development. Nationwide land mapping supports agricultural expansion and land capability assessments. RS-generated climatic grids and digital elevation models identify optimal crop ranges, crucial for mapping areas suitable for diverse horticultural crops.

Conclusion

Geoinformatics has revolutionized agriculture, integrating satellite, UAV, and ground-based sensors for precise crop management. Despite challenges like data complexity and cost, advancing AI and user-friendly workflows is key. Future research should refine parameter estimation and enhance accessibility, promoting sustainable agricultural practices globally.

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IMPORTANCE AND CULTIVATION PRACTICES OF UNDER EXPLOITED FLOWER CROP- *Gomphrena*

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Importance and uses of *Gomphrena*

Gomphrena globosa, commonly known as globe amaranth or Bachelor's button, is an edible plant belonging to the Amaranthaceae family. Its distinctive round flower clusters, known as inflorescences, are prized for their vibrant bracts that come in shades ranging from magenta, purple, and red to orange, white, pink, and lilac. Despite these colorful displays, the true flowers within these heads are small and inconspicuous. Native to Central America, specifically Panama and Guatemala, *Gomphrena globosa* thrives as a tropical annual, blooming continuously from summer through early fall. It is known for its heat tolerance and moderate drought resistance, though it thrives best under full sun exposure and regular watering. The plant fixes carbon through the C4 pathway (Silva *et al*., 2012). The plant reaches a height of up to 61 cm at maturity, with its flower heads growing to approximately 4 centimeters in length. *Gomphrena globosa* is an outcrossing species primarily pollinated by butterflies, bees, and other insects, likely due to the attraction of floral volatiles which contribute to its reproductive success. These flowers are also notable for their rich Betacyanin content, used both as a natural food dye and in cosmetic preparations (Roriz*et al*., 2017).

In herbal medicine, *Gomphrena globosa* has historical uses, while related species like *Gomphrena martiana* and *Gomphrena boliviana* have been utilized to treat gastrointestinal issues. In horticulture, *Gomphrena globosa* is commonly planted in open ground for flower beds and as a border crop to create mass visual impact. Compact varieties are favored for potting, balconies, window boxes, and terraces, while taller types are ideal as cut flowers, particularly for drying. In Hawaii, its resilience in retaining both shape and color after drying makes it a popular choice for long-lasting leis. Additionally, it serves as an indicator plant for potato potexvirus.

Cultivars:

Important cultivars of Gomphrena are, Alba (white), Rubra (Red), Aureo (magenta), Soft Pink (pink), Buddy (purple), Cissy (white) and Strawberry Fields (red flowered, tall cultivar).

Cultivation practices:

Soil and climate:

Well drained garden soil pH of 5.8- 6.2, it is also suitable for alkaline soils with average fertility.It requires full sun for its growth and flowering. This plant grows well in both tropical and sub-tropical climate. Warm season is most suitable.

Propagation: Seed propagation is best method, as seed multiplication ratio is high (1 flower head=80-100 seeds) in this crop. Seeds are sown indoors during early summer during January to

March. It takes 8-10 days for germination. Cuttings of 10-12 cm length are also usedfor propagation.

Transplanting and spacing:
Seedling are ready for transplanting when they attained 3-4 cm height and they are planted in bed at a distance of 20-30 cm. Dwarf cultivars are transplanted 18-20 cm apart.

Irrigation and special operation
Watering should be done immediately after transplanting. Normally, plants are irrigated by flooding once in a week as it is fairly drought resistant crop.

Pinching: The apical portion of plant about 5-6 cm is pinched off to allow lateral growth and to make the stem sturdy at 15 days after transplanting.

Manures and fertilizer
Well rotten FYM @ 10 kg/m^2 is applied at the time of bed preparation. NPK @15-20 g/m^2 should be applied for proper growth and flowering.

Disease and pests:
Leaf spot caused by *Cercospora gomphrenae*is a serious problem in commercial cultivation. Pests like cutworms, aphids and beetles attack the plants at any stages.

Harvesting
Flowers can be harvested when they develop full color. After harvest, flowers remain fresh up to 2-3 weeks. The flowers being hard and dry have long shelf life hence they are highly preferred in dry flower industry. As a dry flower they can be stored for 10-11 months without losing its color.

Yield
The yield varies with cultivars, pinched types yield upto600-650 flowers/plant/year and non-pinched types give520-550 flowers/plant/year.

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HARNESSING REMOTE SENSING AND GIS FOR EFFECTIVE NATURAL DISASTER MANAGEMENT

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Abstract
Remote sensing and Geographic Information Systems (GIS) play critical roles in modern natural disaster management by providing essential tools for detection, assessment, and response strategies. Satellites equipped with advanced sensors monitor environmental changes, enabling early detection of hazards such as hurricanes, wildfires, and floods. GIS integrates spatial data with demographic and infrastructure information, facilitating rapid damage assessment and resource allocation post-disaster. These technologies enhance preparedness through real-time monitoring, accurate risk assessments, and effective response planning. By combining remote sensing imagery with GIS analysis, authorities can prioritize rescue efforts, coordinate evacuation routes, and restore critical services swiftly. Challenges include data integration complexities and the need for enhanced spatial resolution. Future advancements promise to further strengthen disaster management capabilities, fostering resilience and improving global response to natural disasters.

Keywords: Remote Sensing, GIS, Damage assessment, Response planning, Spatial resolution

Introduction

Natural disasters, from hurricanes to earthquakes, tsunamis, wildfires, and floods, have devastating impacts on human lives, infrastructure, and the environment. Rapid and accurate information is crucial for mitigating these impacts and saving lives. Remote sensing satellites orbiting Earth continuously monitor our planet's surface, oceans, and atmosphere, capturing data with a range of sensors that detect changes in environmental conditions. Geographic Information Systems complement remote sensing by integrating spatial data with demographic, infrastructure, and environmental information, providing a comprehensive toolkit for disaster managers.

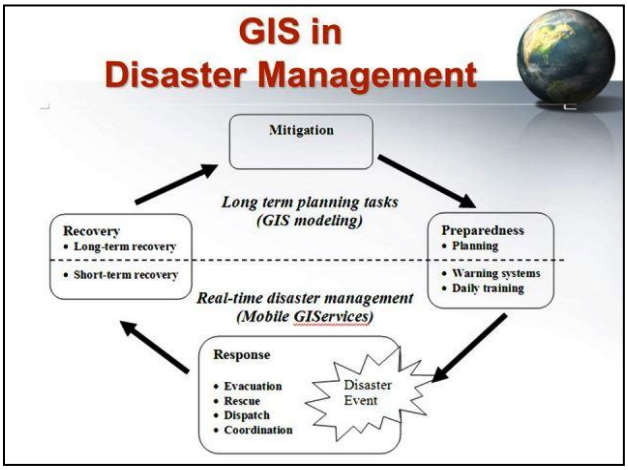

Fig.1. Disaster Management by GIS application

(Source: geostats@journalsci.org)

Detection and Early Warning Systems

Remote sensing plays a pivotal role in detecting and monitoring natural hazards. Satellites equipped with optical and radar sensors can detect changes in weather patterns, monitor sea surface temperatures for hurricane formation, and identify early signs of forest fires or volcanic eruptions (Tomaszewski, 2020). These observations are vital for issuing timely warnings and alerts, allowing authorities to evacuate at-risk populations and prepare response efforts.

Assessment and Damage Estimation

Following a natural disaster, rapid assessment of damage is essential for prioritizing response efforts and allocating resources effectively. Remote sensing imagery provides detailed, up-to-date views of affected areas, enabling disaster managers to assess the extent of damage to infrastructure, agriculture, and natural habitats. GIS platforms facilitate the creation of damage assessment maps by overlaying pre-disaster data with post-event imagery, identifying critical areas needing immediate attention (Kumar & Shankar, 2024).

Response and Recovery Planning

GIS enhances response planning by mapping infrastructure, identifying evacuation routes, and locating emergency shelters. Real-time data from remote sensing satellites support decision-making by providing information on the spread of wildfires, flood extents, and areas cut off by landslides or collapsed infrastructure. These insights enable emergency responders to coordinate rescue missions, deliver aid to affected communities, and restore essential services swiftly.

Building Resilience through Data Integration

Integration of RS and GIS fosters resilience by improving risk assessments and preparedness strategies. Historical data combined with current observations help identify high-risk zones prone to recurring disasters, informing land use planning and infrastructure development policies (Kibon *et al*., 2022). Furthermore, GIS facilitates community engagement by visualizing risk scenarios and involving stakeholders in disaster preparedness and mitigation efforts.

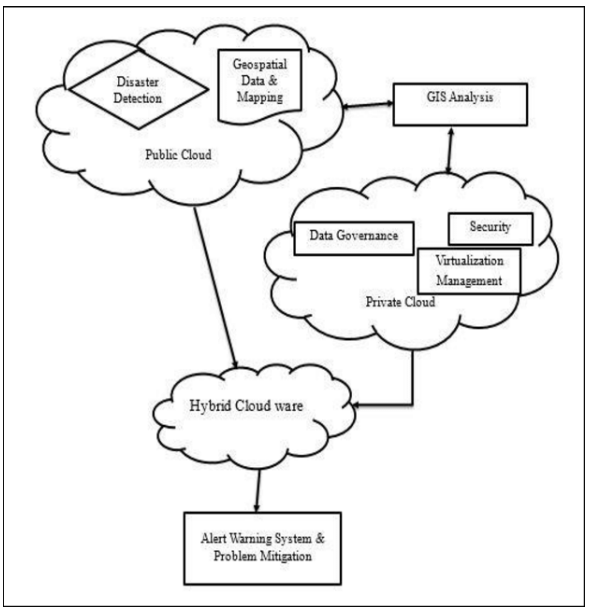

Fig.2. The Decision Making in Cloud GIS for Disaster Management

(Source: Yusoff et al., 2015)

Challenges and Future Directions

Despite their benefits, challenges such as data accessibility, processing capabilities, and integration across different platforms remain. Future advancements in satellite technology, including higher spatial and temporal resolutions, and advancements in machine learning algorithms for data analysis, hold promise for enhancing disaster management capabilities. Moreover, fostering international collaborations and sharing data globally are crucial steps toward improving global resilience to natural disasters.

Conclusion

Remote sensing and GIS technologies are indispensable tools in modern natural disaster management, offering real-time data, spatial analysis capabilities, and decision support systems that empower authorities to mitigate risks, respond effectively, and facilitate recovery. As these technologies continue to evolve, their potential to enhance resilience and save lives in the face of increasingly frequent and severe natural disasters becomes ever more critical.

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BREAKTHROUGH IN HATCHERY TECHNOLOGY AND FEEDING STRATEGIES FOR GIFT TILAPIA

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Abstract
In recent years, significant advancements have transformed the hatchery technology and feeding strategies for GIFT (Genetically Improved Farmed Tilapia) tilapia, revolutionizing aquaculture practices worldwide. This article explores the innovations in hatchery techniques tailored to enhance breeding efficiency and genetic quality, ensuring robust stocks for sustainable aquaculture. Additionally, it delves into modern feeding strategies designed to optimize growth rates, health, and nutrient utilization in GIFT tilapia, thereby bolstering productivity while minimizing environmental impact. By examining these developments, aquaculture enthusiasts and industry stakeholders gain insights into how technological progress is shaping the future of fish farming, promising improved efficiency and sustainability in global food production.

Introduction

Aquaculture worldwide has been the fastest-growing food production sector. The implementation of novel technology and the methodical enhancement of pre-existing technologies were pivotal in enhancing the efficiency, economy, ecological sustainability, and regulatory compliance of aquaculture production. Control over the production process has been identified as a driving factor for aquaculture development (Anderson, 2002; Asche, 2008). The ability to supply inputs and harvest when needed (i.e., fingerlings, broodstock, properly balanced diets, etc.) allows for systematic research and development leading to innovations improving productivity (i.e., production of greater output from a given set of inputs or production of the same output with fewer inputs). Successful innovations often increase productivity (by improving the input/output ratio) and economize the use of inputs and processes, thus resulting in a new production function.

Hatchery technology of GIFT

Nile tilapia is the sixth most important farmed species worldwide in terms of value, but the third most important of those traded internationally, following white-legged shrimp and Atlantic salmon. In terms of quantity produced, tilapia is more important than salmon and shrimp. Unlike white-legged shrimp and Atlantic salmon, tilapia species have been cultured for millennia with evidence of harvest of cultured tilapia from ancient Egyptian tombs dating back to 900 B.C. (Bardach et al., 1972). Tilapia differ from shrimp and salmon in that they are grown as a subsistence crop in many developing countries across the world, but are also grown as a high-value crop for domestic urban markets (as in Egypt and Brazil) and for export (Norman-Lopez and Bjørndal, 2009).

History of GIFT

The initial success of tilapia farming in its early phase of development was due primarily to technologies that enabled farmers to control reproduction. Although manual culling of females

was the simplest way to ensure the selection of faster-growing male tilapias, this method was laborious and prone to errors. Hybrid production technologies provided an initial impetus for managing early sexual maturation and the prolific reproduction of tilapias (Gupta and Acosta, 2004). The introduction of the faster-growing and slowly maturing Nile tilapia (*O. niloticus*) in the early 1980s led to the development of several inter-specific hybrids. Prominent among these were the Taiwanese red hybrid tilapia (mutant reddish-orange female *O. mossambicus* X normal male *O. niloticus*) and the Israeli red hybrid tilapia (cross of Egyptian Nile tilapia X wild blue tilapia *O. aureus*), which had superior growth, greater salinity tolerance, and a distinctive red color (Hulata et al., 1995). The other prominent hybrid was the Florida red tilapia (cross of normal *O. hornorum* female with a red-gold male *O. mossambicus*) with faster growth, greater tolerance to high density, and the ability to produce a greater percentage of males in the population (Wohlfarth and Hulata, 1994). Despite the development of hybrids to control reproduction, the majority of the tilapia produced in the initial phase of industry establishment continued to be in extensive or modified pond culture. Fish yields increased through pond fertilization and the use of supplemental feeds; often pelleted feeds formulated for other livestock. Although these production methods were profitable for semi-subsistence level farms, such extensive systems were not profitable for large farms that produced fish for export.

One of the key commercial technologies adopted in the 1991–2000 early growth phase of tilapia was that of sex reversal of tilapia fingerlings with the androgen, 17- a-methyl testosterone, to produce all-male populations. The sex-reversal technology produced a consistent supply of faster-growing males and prevented problems of unwanted reproduction, overcrowding, and harvest of undersized fish. Dissemination of sex-reversal technology led to the expansion of food fish production around the world (Phelps and Popma, 2000). As a result, tilapia production grew by 12% per year from 1991 to 2000.

The tilapia industry entered a phase of rapid growth beginning in 2001 with an average annual growth of 11% from 2001 to 2012. A major factor in this rapid growth was the adoption of Genetically Improved Farmed Tilapia (GIFT). Many of the major Asian producers such as China, the Philippines, Thailand, and Indonesia adopted the GIFT strain, and GIFT tilapia accounted for more than half of the production in Asia in 2012. While the GIFT breeding program emphasized growth for tilapia, other traits like survival, disease resistance, and age at maturation were also selected (Gupta and Acosta, 2004). The accumulated genetic gain was over 64% from the base population with a 7% gain per generation. Improved strains of tilapia have significantly increased the productivity, farm output, and profit levels associated with tilapia farming, leading to wide-scale adoption in China and other countries. The lower costs of producing GIFT strains as compared to non-GIFT strains benefitted both farmers and consumers (Dey and Gupta, 2000).

Synchronization of spawning

Spawning should be synchronized to produce progeny groups as uniform in size and age as possible. This will reduce the confounding effects of initial size and age during comparative studies of different genotypes (e.g. strains, cross combinations, family groups), and in the estimation of various genetic parameters (e.g. heritability and genetic correlations) and breeding values. Spawning of Tilapias is influenced by both environmental (e.g. photoperiod, temperature, food availability) and social factors (social stimuli exchanged between neighboring females). Therefore, the strategy for synchronizing spawning involves maintaining broodstock separated by sex in a

suitable holding facility, conditioning by proper feeding, and evaluating the sexual maturity condition of females.

Potential male and female breeders should be kept separately in hapas installed in fertilized ponds at a stocking density of three fish per hapa if their live weight is up to 200 g, and two per hapa if the fish are heavier. Because of the generally greater live weight and more aggressive behavior of males, these may have to be stocked at a lower density per hapa. Individual breeders will then be exposed to the same reproduction-triggering factors at the same time. Furthermore, holding potential female breeders together might help synchronize spawning by exchanging social stimuli (e.g. pheromones). Stocking of breeders in hapas makes the handling and retrieval of fish during the selection of breeders relatively easy. Conditioning may also take place in larger hapas [e.g. 1.5 m (width) by 4 m (length) by 1 m (depth)]. In such cases, the stocking density may be up to 20 fish per hapa.

Conditioning of breeders

Breeders should be conditioned at least two weeks before stocking in breeding hapas. During conditioning, Tilapia breeders are fed a balanced feed (about 30 percent crude protein) at a feeding rate of 2 to 5 percent of their body weight.

Evaluation of sexual maturity condition

After conditioning, the female breeders should be checked for their readiness to spawn by visually examining their morphological characteristics. Female breeders are then categorized in one of the following maturity conditions: 'ready to spawn' (RS), 'swollen' (S), 'not ready to spawn' (NRS), and 'has spawned' (HS). Female breeders categorized as 'ready to spawn' are first selected for pairing with a male in a breeding hapa.

Breeding in hapas

Tilapias are known to spawn in tanks, ponds, or small cages (breeding hapas) within ponds. The GIFT technology uses breeding hapas (1 x 1 x 1 m^3) installed in a pond to enable a controlled production of many full and half-sib families.

Preparation of facilities

The breeding pond should first be drained, and then allowed to dry for at least two weeks before liming and refilling with water at a level of 80 cm. Liming is usually carried out at a rate of 100 to 300 g per square meter. The water inlet and outlet should be covered with a fine-meshed wire screen to prevent the entry of predators into the pond. One or two weeks prior to stocking the breeders, the pond should be fertilized [2,000 kg chicken manure and 100 kg inorganic fertilizer (N: P: K in the ratio 16:20:0) per ha] to stimulate the production of natural food. Breeding hapas should then be installed in the pond in rows with enough space to enable water circulation. Breeding hapas for two females to be mated with the same male are installed opposite each other to facilitate an easy transfer of the male.

Mating design and procedure

A mating plan should be prepared combining all selected breeders. Generally, each male breeder is mated at random to two female breeders in a nested mating design to produce paternal half-sib families. This will allow the calculation of phenotypic and genetic parameters (i.e. heritability, phenotypic, and genetic correlations), which are necessary for calculating breeding values. It is important to avoid mating of closely related individuals (i.e. full-sibs, half-sibs, or cousins) to prevent inbreeding depression.

Stocking of breeders

The female breeders should be stocked into the breeding hapas before the males. The males are then transferred to the females that are most ready to spawn. After fry is produced and collected, the males are separated from the females and immediately transferred to the hapa where the second female is stocked. Spent females that produce less than 200 fries should be conditioned (by proper feeding) in the breeding hapa and mated again with the same male until they produce a satisfactory number of fries. The Tilapias being mated should not be fed when the female breeders are expected to spawn since this might cause the females to swallow the eggs.

Mouth clipping of males

To avoid, or at least reduce, mortalities the body weights of female and male breeders should be as close as possible to each other. If the male breeders are much larger (say, greater than 30 percent) than their female counterparts, it is necessary to carry out mouth clipping of male breeders before transferring them to the breeding hapas. The male breeders should be anesthetized before removing their upper lips, and the wounds should be disinfected using an antiseptic preparation (e.g. Betadine, 10 percent solution).

Fry collection

The first fry collection may be done 10 to 14 days after stocking the breeders. The hapa is first divided into two compartments to separate the female and male breeders to reduce stress when checking the females. The fry should be collected early in the morning to avoid stress and mortalities. Females with incubating eggs or yolk sac fry in their mouth should remain in the breeding hapa until yolk absorption is complete or until the fry is in the free-swimming stage. Eggs or yolk sac fry that have been accidentally released from the mouth of the female can be collected and transferred to artificial incubators. Both fry and eggs should be rinsed and counted before transferring them to the nursery hapas or artificial incubators.

Artificial incubation

Eggs or yolk sac fry that are accidentally released from the female breeders can be transferred to artificial incubators. It is important to ensure a constant flow of water to the incubators to optimize the environment for the eggs or yolk sac fry. The eggs usually hatch after 2 or 3 days. The fry is incubated until yolk absorption is complete and is then transferred to nursery hapas.

Feeding

A tank-based or hapa-based hatchery is selected that will allow fry to be collected at the yolk sac or first feeding stages (no later than one week after they have been released from the female). Transferred healthy fry of uniform size to the tank or hapa where you will feed them with the hormone-laced diet for 21-28 days The sex reversal feed is prepared as follows:

- Mix 30 - 70 mg of hormone (methyl or ethynyl testosterone) in 700 ml of 95% neutral ethanol.
- Add 700 ml of hormone solution to each kg of finely ground feed then mix thoroughly and dry. At this stage, you may add any needed supplements
- This feed should be kept under refrigeration if it is not going to be used immediately
- Feed the fry at a rate of 10 - 30% of body weight per day, at least four times a day for 21 - 28 days.
- The fry must eat this feed to sex-reverse

Tilapia males are preferred for culture because they grow faster than females. Females use considerable energy in reproduction and do not eat when they are incubating eggs. Males-only culture permits the use of longer culture periods, higher stocking rates, and fingerlings of any age. High stocking densities reduce individual growth rates, but yields per unit area are greater. If the growing season can be extended, it should be possible to produce fish of up to 500 grams. Expected survival for all-male culture is 90 percent or greater.

Conclusion

In conclusion, the evolution of hatchery technology and feeding strategies for GIFT tilapia marks a pivotal advancement in aquaculture. These innovations have not only enhanced efficiency and profitability but also promoted environmental sustainability and compliance with regulatory standards. By integrating systematic improvements in breeding, feeding, and production practices, aquaculture has achieved substantial gains in productivity and resource utilization. The widespread adoption of technologies like sex reversal and genetic improvement through GIFT strains has propelled the tilapia industry into a phase of rapid growth and global prominence. Looking ahead, continued research and development in hatchery techniques and feeding regimes promise further enhancements in the quality and yield of GIFT tilapia, ensuring a robust and sustainable future for aquaculture worldwide.

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MUSHROOM CULTIVATION – IT'S TECHNICAL KNOW HOW

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Introduction

Mushrooms are integral to diversified farming, serving as efficient converters of agricultural and agro-industrial waste into highly nutritious food sources. The by-products of mushroom cultivation can be further utilized to produce compost or as inputs for vermicomposting, enhancing sustainability in agricultural practices. Beyond their ecological role, mushrooms significantly contribute to income generation, presenting substantial opportunities both globally and nationally. In India, mushroom cultivation occurs seasonally and under controlled conditions tailored to various climatic zones. Button mushrooms thrive in temperate regions, while oyster, milky, and paddy straw mushrooms flourish in tropical and subtropical climates. Seasonal cultivation of button mushrooms is feasible in regions where winter temperatures dip below 20°C. Conversely, summer white button mushrooms can thrive in subtropical areas with temperatures up to 24°C. Oyster mushrooms encompass species suitable for both temperate and subtropical climates; notable varieties include *Pleurotus ostreatus*, *P. florida* (winter strain), *P. fossulatus* (Kabul dhingri), and *P. eryngii* (King oyster). Most oyster mushroom species thrive in subtropical conditions, with optimal growth occurring within a temperature range of 20-32°C. Common subtropical species include *P. sajor-caju*, *P. florida*, *P. flabellatus*, and *P. eous*. Paddy straw mushroom cultivation is primarily concentrated in Odisha, thriving in temperatures ranging from 25-40°C. Milky mushrooms are predominantly cultivated in select parts of South India, flourishing at temperatures between 30-35°C.

Cultivation of White Button Mushroom

Compost preparation:

The ingredients for synthetic compost are wheat straw, bran (rice or wheat), urea, gypsum, calcium ammonium nitrate or ammonium sulphate. The straw must be chopped to 8-20 cm. in length. It is spread uniformly to form a thin layer on the composting yard. The straw is then drenched thoroughly by sprinkling water. The next step is to mix all other ingredients like Gypsum (65Kg), Urea (12.5 Kg), SSP (12.5 Kg), calcium ammonium nitrate (12.5 Kg), Wheat bran (50 Kg) with the wet Paddy straw (1000Kg) and heap them into a pile. The pile must be turned regularly as per the following schedule:

No. of Turns	Days	Ingredients to be added
1st Turn	6th day	Nil
2nd turn	10th day	Nil
3rd turn	13th day	65 Kg Gypsum
4th turn	16th day	Malathion spray @ 1ml/lit of water
Final Turn	28th day	Nil

During each turn, ensure to thoroughly moisten the heap by sprinkling water to replenish any lost due to evaporation. For the final turn, break the heap to release any excess gas; otherwise, conduct another turning after 2-3 days if necessary. Prior to spawning, treat the final compost with a solution of 1.5 liters of Formalin and 50 grams of Carbendazim 50 WP mixed in 40 liters of water.

Spawning:
Spawning involves sowing mushroom mycelium into prepared beds. First, fill trays with compost, ensuring a depth of 15-18 cm. Spawning can be done by scattering compost on the bed surface or by mixing grain spawn with compost before filling the trays. Cover the trays with old newspaper sheets and sprinkle the surface with water to maintain moisture and humidity.

Casing:
The spawn run is complete when white cottony growth appears. Apply casing soil to the compost surface, covering it to a thickness of up to 3 cm. Casing soil is prepared by mixing finely crushed and sieved rotten cow dung with garden soil, aiming for an alkaline pH of at least 7.4. Sterilize the casing soil using half a liter of formalin in 10 liters of water, either through formalin treatment or steaming. Maintain a temperature of 25°C for 72 hours, then reduce it to 18°C during the casing stage, which requires ample ventilation.

Cropping:
Pinheads become visible 15 to 20 days after casing, with small white buttons developing within 5-6 days. Harvest mushrooms when the caps are firmly attached to the short stem.

Harvesting:
When harvesting, gently twist the cap off by holding it with the forefingers, pressing against the soil, and twisting gently to detach.

Cultivation of Oyster Mushroom
Oyster mushrooms are commonly cultivated using paddy straw as their primary substrate, although they can also thrive in wheat straw, sugarcane bagasse, sawdust, and other materials. Initially, the straw is cut into small pieces measuring 2-3 inches in length. These pieces are soaked in water and cleaned thoroughly. Subsequently, the fresh straw undergoes treatment in a solution containing 125 ml of Formalin and 10 g of Carbendazim 50WP mixed in 100 liters of water, a process that lasts for 12-16 hours within a concrete tank.

The following day, the treated straw is removed from the tank and allowed to drain excess water. It is then spread out on a clean floor treated with formalin. Lime is evenly mixed with the straw at a rate of 1 gram per kilogram of straw. Next, the straw is combined with mushroom spawn and layered either inside polythene bags or alternated in trays with additional straw layers. The bags are securely tied and placed on elevated platforms for 18 to 20 days. Pin holes are punctured in the bags to facilitate adequate aeration.

Once mycelium becomes visible inside the polythene bags and covers the surface of the paddy straw, the bags are crosswise cut by 1 inch in 4-6 places or gently removed. Light water spray is then regularly applied at this stage. Approximately 4-5 days after cutting or removing the polythene, pinheads begin to emerge. Within another 3-4 days, mushrooms can be harvested by

gently twisting the bunches off the substrate. Regular water spray is continued throughout this period.

Following the first harvest, subsequent crops can typically be harvested every 7-10 days, with a total of three harvests achievable from each polythene bag. Oyster mushrooms prefer a temperature range of 20-32°C and require a relative humidity of 75% or higher for optimal cultivation.

Cultivation of Paddy Straw Mushroom

It thrives in temperatures ranging from 30-40°C when cultivated on paddy straw. Other tested substrates include sugarcane bagasse, cotton wastes, and water hyacinth. In India, species of Volvariella commonly cultivated include *V. esculenta*, *V. displasia*, and *V. valvacea*.

For the cultivation of *V. volvacea*, the polybag method is employed, involving the following steps:

1. Chop the paddy straw and soak it in water for 24 hours.
2. Cut waste paper into small pieces and soak it for the same duration.
3. Drain the water after 24 hours.
4. Thoroughly mix the chopped straw, paper pulp, and spawn.
5. Fill the mixture into polyethylene bags.
6. Puncture the bags with a needle to facilitate air exchange and water drainage.
7. Tie the mouth of the bag and place it in an environment maintained at 35-40°C.
8. Carefully cut and remove the polyethylene bag to leave its contents undisturbed.
9. Maintain humidity levels of 85-90% by regularly spraying water.
10. After 10-15 days of incubation, small pins begin to grow.

Conclusion

Mushroom cultivation in India exemplifies sustainable agricultural practices by efficiently utilizing agricultural and industrial waste to produce nutritious food sources. The cultivation of white button, oyster, and paddy straw mushrooms demonstrates the versatility of mushroom farming across different climatic zones and substrates. By adopting these practices, farmers not only contribute to food security but also promote environmental sustainability through waste reduction and recycling. As global demand for nutritious and sustainable food sources continues to rise, mushroom cultivation stands as a promising avenue for economic growth and agricultural innovation in India and beyond.

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INSECT DEFENCES: FROM CAMOUFLAGE TO CHEMICALS

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Abstract
Different antipredator defence tricks have evolved in insects. For instance, many insects have developed crypsis and use cryptic body colours and shapes to camouflage themselves from predators. Some toxic insects are aposematic, with bright body colours for advertising their toxins, while others manufacture toxins as a sort of chemical defence against predators. In order to defend themselves from predators, insects can also grow hairs, spines, or hard exoskeletons. Additionally, insects can develop behavioural defences such as autotomy, falling, or feigning death. Thus, it may be claimed that insect defences have been a major factor in insects' rise to the top of the food chain on the surface of the world.

Keywords: behavior, coloration, defense, mimicry

Introduction

Predation is the main factor in shaping prey species through natural selection. In order to survive in a world with different predators, animals have created a wide variety of defence mechanisms **(Eisner *et al*., 2005)**. Insects typically have two options when faced with a predator: flee or fight. They're both really energetically draining. However, there are other options, the least energy-intensive, probably concealment (crypsis) and fake death (thanatosis) **(Day, 2011)**. To avoid being eaten by predators, many insects have developed camouflage (such as cryptic body colours). Certain insects have developed mechanisms such as poisonous compounds, hairs, spines, or tough exoskeletons. Additionally, many insects engage in defence strategies such autotomy, and dropping, and death to avoid being eaten.

Types of Antipredator Defenses: Antipredator defences in insects entails the interaction of the two functional categories of passive or active defence. The passive defence or primary defence, is the prey's attempt to avoid being discovered by the predator. This accomplished through hiding or changing the time of activity, aposematism, and crypsis. They don't demand any specific action and are always present. Other defenses only begin to function once real contact with a potential foe has occurred. Secondary defences often call for an action or reply from the insect, and can be seen as active communications. Active escape, flash colouring, chemical production, and death impersonation are examples of secondary defences **(Matthews and Matthews, 2010)**. Chemical, morphological, and behavioural defences comprise both primary and secondary defences.

Insect defences thrives under following categories

Behavioral: Includes autotomy, death feigning, falling, jumping, and flying. Stick insects and grasshoppers can autotomize their legs to free themselves from predators' grasp. Insects like stick insects, crickets, beetles, larvae of damselflies, ants and wasps, also demonstrate death feigning.

In case of dropping, the larvae of moths use silk threads to suspend themselves from their host plants. When they drop, they can climb the threads to get back to their host plants. Many insects are able to evade predators by using their ability to jump, including fleas, grasshoppers, crickets, and leafhoppers, whilst winged insects may fly. In reaction to predator attacks, some katylids, butterflies, moths, and praying mantises perform startle *i.e*., deimatic displays by abruptly showing a posture that shocked the predator and ceases the attack.

Structural: The sclerotized integument offers defense against any natural attack, even bird beaks. Long body hairs have developed in some lepidopteran larvae to shield their fragile bodies from predator mandibles and parasitic ovipositors. The spines on ants and dragonfly larvae serve as physical protection against predators. Furthermore, rigid exoskeletons, like those of weevils, serve as physical deterrents to predators.

Colouration/Morphological: Four types of defensive or, more precisely, protective color patterns can be identified: aposematic defense, flash patterns (eye patterns), cryptic coloration, and mimicry.

Camouflage (I'm not here)

Crypsis is an insect's ability to camouflage its shape so they can readily blend into their environment. An insect uses camouflage when it changes its shape, pattern, or coloration in order to hide from predators. In order to mimic, many insects have evolved cryptic body parts or colors, for example, a green katydid or a green hopper on green foliage. Insect resemblance to inanimate objects include homomorphism (shape), homochromism (colour), and homotypism (form and colour). The pine beauty moth (*Panolis flammea*) caterpillars are hard to distinguish because of their dark green coloration, which makes them resemble the pine needles they reside amid. It is challenging to see the horned treehopper. On the prothorax, it contains three projections: two that are bent laterally and one that is larger and runs backwards. The treehopper looks like a plant stem thorn.

Aposematic defense

The use of warning colours to alert potential predators that an animal is toxic, venomous, or harmful is known as aposematism. The *Dissoteira carolina* (Carolina locust), has a loud crackling sound and bright yellow and black colouring. Brightly coloured bees and wasps produce a warning buzz that is convincing enough to be imitated by a wide range of unrelated species. Some animals adopt chemical defence as a last resort and do not promote it, despite the fact that many vile-tasting prey are aposematic.

Mimicry (I'm someone else)

Mimicry is the similarity of one organism (the mimic) to another organism (the model), in terms of colour, pattern, structure, or behaviour. Batesian mimicry is the phenomenon in which an edible species develops an appearance like that of an unsavoury, poisonous, or otherwise protected one. Mullerian mimicry is the imitation of warning signals by two or more relatively unrelated insects that are all repulsive or otherwise protected. Aggressive mimicry is one of the more well-known examples. James E. Lloyd discovered that females of the genus Photuris (also known as "femmes fatales") emit the same light signals used by females of the genus Photinus as a mating signal. As a result, male fireflies from genera Photinus are drawn to these "femmes fatales" and are eaten as a result.

A. Chemical/Systemic defense (I'm noxious): Venomous chemicals are a general category for chemical defence among insects. Ants, beetles, butterflies, moths, and termites are just some of the insects that create poisonous substances to ward off predators. The buildup of steroids produced by their hosts protects the aphids that dine on milkweed and oleander against predators. Chemicals already present in prey or host plants can be "borrowed" as a source for defense compounds. For instance, monarch butterfly larvae can safely feed on milkweed plants, despite the fact that the plants' sap contains cardiac glycosides, which are very toxic to birds. The monarch butterfly stores the poisons in the veins of its wings and used against predators.

B. Group defense or Group action (Mobbing) (We are in this together): The well-known behavioural adaptation of eusocial insects is group defence. In true military fashion, certain Nasutitermes termites make incursions above ground during the day. Rows of soldiers, with their spraying snouts facing outward, defend the workers from invading arthropods. When the nest of a ant, *Formica rufa* is disturbed, the insect's workers immediately emerge and spray formic acid towards the direction from which the sound originated.

Conclusion

This exploration of self-defense demonstrates how evolution has employed a wide range of methods and techniques to give animals weapons for fending off predators. There are three pillars of defence against predators: staying undetected, escaping, and counterattacking. Background matching, countershading, and disorienting hues can all be used for effective concealment, or cryptic design. The outcome of these various colour and form patterns is usually the same: they make the animal challenging to see. In contrast to camouflage, mimicry typically resembles another living thing. Palatable or helpless prey that mimics unpleasant or hazardous animals are known as batesian mimics. Mullerian mimics are toxic, unappealing prey that imitate other toxic, unappealing prey, increasing the likelihood that a predator may have a bad encounter with these species. Through the diluting effect, the presence of a group can reduce an individual's risk. The insect's arsenal of defences goes much beyond the defences mentioned above that still needs to be discovered.

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INTEGRATED PEST MANAGEMENT (IPM) IN MANGO FOR SUSTAINABLE PRODUCTION SYSTEM

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Abstract
Integrated Pest Management (IPM) has emerged as a sustainable approach to managing pests in agricultural systems, including mango orchards. This review synthesizes current knowledge on IPM strategies specific to mango cultivation, focusing on pest identification, monitoring techniques, cultural practices, biological control methods, and the integration of chemical control where necessary. The effectiveness, challenges, and future directions of IPM in mango farming are discussed, highlighting its potential to enhance yield, reduce pesticide use, and promote environmental and economic sustainability.

Keywords: Integrated Pest Management, mango orchards, pest control, biological control, cultural practices, sustainable agriculture

Introduction

Mango (*Mangifera indica* L.) is one of the most important tropical fruits globally, valued for its nutritional content and economic significance. However, mango cultivation faces numerous challenges from pests and diseases, which can significantly impact yield and fruit quality. Traditional pest control methods often rely heavily on chemical pesticides, raising concerns about environmental pollution, pesticide residues, and health risks. In response, Integrated Pest Management (IPM) has gained traction as a holistic approach to pest management, aiming to minimize pesticide use while maintaining pest control efficacy.

Pest identification

Effective IPM begins with accurate pest identification and monitoring. In mango orchards, common pests include fruit flies, mango hoppers, scales, mealy bug, and stone weevil.

1. Hoppers (*Idioscopus niveoparsus, I. clypealis* & *Amritodus atkinsoni*): The wedges shaped nymphs and adult insects puncture and suck sap of tender parts, reducing vigour of plants and particularly destroying the inflorescence and causing fruit drop. Heavy puncturing and continuous draining of sap causes curling and drying of infested tissue. Hoppers are widely distributed in all mango growing areas of India.

2. Thrips (*Scirtothrips dorsalis*): Nymphs and adults lacerate the tissues and suck the oozing cell sap. Leaf feeding species feed on mesophyll near leaf tips. Affected leaves show silvery sheen and bear small spots of faecal matter. Thrips are widely distributed in all mango growing areas of India.

3. Mealy bug (*Drosicha mangiferae*): The adult bugs are covered with whitish powder and colonize between bark of tree trunk, young shoots and panicles causing flower drop, affecting fruit set. They also excrete honey dew, a sticky substance, which facilitates development of sooty mould. Mealy bugs known to occur in all mango growing areas of India.

4. Scale Insects (*Aspidiotus destructor*, *Ceroplastis* sp.): The nymph and adult scales suck the sap of the leaves and other tender parts and reduce the vigour of the plants. They also secrete honeydew, which helps in the development of sooty mould on leaves and other tender parts of the tree. Scale insects are occurring in all mango growing areas of India.

5. Shoot Borer (*Chlumetia transversa*): Larvae bore into the young shoot by tunneling downwards resulting in dropping of leaves and wilting of shoots. Larvae also bore into the inflorescence stalk. Female moths lay egg on tender leaves. Widely distributed in India.

6. Fruit flies (*Bactrocera dorsalis, B. correcta & B. zonata*): The female punctures outer wall of mature fruits with the help of its pointed ovipositor and insert eggs in small clusters inside mesocarp of mature fruits. On hatching, the maggots feed on fruit pulp and the infested fruits start rotting due to further secondary infection. Mango fruit flies distributed all over mango growing areas.

7. Stone weevil (*Sternochetus mangiferae*): Adult weevils are stout and dark brown, grubs are white legless and stumpy. On hatching grubs bore through the pulp, feed on seed coat and later damage the cotyledons. Pupation is inside the seed. Stone weevil prone to attack on Totapuri, Neelam, Banglura and Banganpalli varieties and distributed in southern parts of India.

8. Fruit borer (*Deanolis albizonalis*): Hatched larvae bore into fruits. Fully grown caterpillars have red bands on body alternating with white bands caterpillars bore into the fruit at the bottom (beak region) and feed inside reaching Kernels. Entrance hole is plugged with excreta. Affected fruits rot and fall prematurely. This pest is widely distributed in Andhra Pradesh and Orissa.

Pest Monitoring

Monitoring techniques such as pheromone traps, sticky traps, and visual surveys are employed to assess pest populations and dynamics, enabling timely intervention. Surveillance on pest occurrence in the mango field should commence soon after crop establishment and at weekly intervals thereafter by walking across the field and choosing 300 fruits from 20 trees/acre randomly across the diagonal of the field. For fruit flies/mealy bug count and record the number of both nymphs and adults on five randomly selected fruits/leaves per plant. For leaf webbers count the number of webs formed in each direction, thus covering the whole tree. Number of scale infested shoots per five tender shoots from each of the four directions of the selected tree should be counted for scale insects. For defoliators/borers count the number of young and grown up larvae on each plant and record. Pest monitoring for fruit flies using methyl eugenol should be done regularly from fruiting stage onwards.

Cultural and physical control practices

Cultural practices play a crucial role in IPM by manipulating the orchard environment to deter pests or disrupt their life cycles. Techniques such as pruning, mulching, and orchard sanitation reduce pest habitats and improve air circulation, thus minimizing disease incidence and pest populations. Physical barriers, such as netting to exclude fruit flies or protective covers, can prevent pest access to mango fruits.

For the management of mealy bugs, flooding of orchard with water in the month of October kill the eggs, ploughing of orchard in November, raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds, fastening of alkathene sheet (400 gauge)/grease band of 25 cm wide afterwards mud plastering of trunk at 30 cm above the ground in the middle of December can be followed.

For the management of fruit flies, prior to harvest (30-40 days) collect and disposed off infested and fallen fruits to prevent further multiplication and carry-over of population, ploughing of orchard during November-December to expose pupae to sun's heat which kills them, on heavyinfestation bait splash on the trunk only once or twice at weekly interval is recommended. To prepare bait splash, mix 100 gm of jaggery in one litre of water and add 1 ml of deltamethrin by using an old broom. Managing fruit flies also reduces anthracnose disease and prevents late fruit fall.

Mechanical control

Male annihilation technique for fruit fly:

Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/l of water + 1 ml of malathion solution.Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the adult flies.

Biological Control Agents

Biological control forms a cornerstone of IPM in mango orchards, harnessing natural enemies to suppress pest populations. Predators and parasitoids, including *Rodolia fumida*, *Suminusrenardi*, Coccinellids, *Beauveria bassiana*, *Verticillium lacani*, *Malladaboninensis*, *Podynema* spp., *Platygaste r*sp, *Eupulmus* sp., *Systasisdasynearue*, *Micronimustimidis*, *Baccha pulchrifrons*, etc. are utilized to target specific pests while preserving beneficial organisms.

Application of bio-agents, *Metarhizium anisopliae*@ 1x 108 cfu/ml or *Beauveria bassiana*@ 108 cfu /ml on tree trunk once during off season and twice at 7 days interval during flowering season for the management of hoppers.

Chemical Control and Integration

While minimizing reliance on chemical pesticides is a key principle of IPM, judicious use of pesticides may be necessary in certain situations. Selective pesticides with low environmental impact and short residual effects are preferred, targeting specific pests during critical periods while sparing natural enemies. Integrated approaches combine chemical control with other IPM strategies to maximize efficacy while reducing pesticide load.

Recommended pesticides against Mango insect pests (CIB&RC)

Pests/Pesticides	Dosage			Waiting Period (days)
	a.i (gm)	Formulation (gm/ml)	Dilution (Litre)	
Hoppers				
Buprofezin25% SC	0.025% to 0.05%	1-2 ml/liter of water	5-15 liter/tree	20
Deltamethrin2.8% EC	0.03- 0.05%	0.33 to 0.5 ml/lit	-	1
Imidacloprid17.8% SL	0.4 – 0.8 g/tree	2-4 ml/tree	10 litre	45
Lambdacyhalothrin5% EC	0.0025- 0.005%	0.5-1.0 ml/l water		7
Thiamethoxam25% WG	25	100	1000	30

Challenges and Limitations

Despite its advantages, IPM implementation in mango cultivation faces several challenges. These include knowledge gaps in pest biology, limited availability of effective biological control agents,

and economic constraints for small-scale farmers. Adoption barriers, such as resistance to change and access to training and resources, also hinder widespread application of IPM practices.

Future Directions and Recommendations

The future of IPM in mango farming lies in advancing research and extension efforts to address existing challenges. Enhancing pest monitoring technologies, developing region-specific IPM protocols, and promoting farmer education and collaboration are crucial. Integrating new technologies, such as precision agriculture and digital tools for pest monitoring, can further optimize IPM strategies in mango orchards.

Conclusion

Integrated Pest Management offers a sustainable approach to managing pests in mango orchards, emphasizing ecological balance, reduced chemical inputs, and enhanced farm profitability. Continued research, stakeholder collaboration, and policy support are essential to foster widespread adoption of IPM practices and ensure the long-term sustainability of mango production.

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MEAN: A MEASURE OF CENTRAL TENDENCY

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Abstract
Measure of central tendency is a measure, located at the centre point, around which, most of the other values tend to cluster and therefore it is also called as a measure of location. The three common measures of central tendency are mean, median and mode. One statistical technique that appears to be widely used in research is a measure of central tendency. The mean, median, and mode are the three most widely used metrics to determine central tendency, theoretically. All three of the metrics are considered valid and suitable for various scales and/or situations.

Since research covers a large area of studies, regular use of all these three measures should be assumed. However, in most of research reports which include a description of central location of data, the mean seems to be an only method found to be used.

Keywords : Central tendency, Arithmetic mean, geometric mean, harmonic mean

Introduction:
Central tendency is defined as the statistical measure that represents a single value for an entire distribution. Attempts to accurately describe all of the data using the so-called Pythagorean means—the arithmetic, geometric, and harmonic means. (Chakrabarty, 2019): "Pythagorean Geometric Mean: Measure of Relative Change in a group of variables).

The statistical notion of measure of central tendency or central location is used to characterize the entire set of data.In other words, it explains the global behaviour of all samples in an average manner. It is a statistical tool that defines/describes the entire data set in one single value as well as compares different data sets. (Prasad,2023).

The average is an appropriate way to summarize the data as it considers all values within the dataset. The irony here is that, in most cases, the raw data never shows this value. The means of repeated samples taken from the same population are typically comparable. The mean is the central tendency measure that exhibits the highest resistance to variation across different samples.

Objectives of averaging

- To determine a single value for the whole set of data.
- To describe the characteristics of the entire group of data
- To help in comparison of different data within one group

Characteristics of an ideal measure of central tendency

- It should be rigidly defined

- It must be simple to comprehend and straightforward to compute.
- It ought to be appropriate for additional mathematical analysis
- It should be least impacted by variations in the sampling process.

Measure of Central Tendency is Classified as:

Central tendency or average

Mathematical averages	Partition averages	Positional
•Arithmetic mean(AM) •Harmonic mean(HM) •Geometric mean(GM)	•Median •Mode	•Percentile •Quartile •Decile

Arithmetic mean:

Arithmetic mean of a series is a figure or number obtained by dividing sum of value of all observation, by the total no. of observation.

It is described to be a method of central tendency which can offer a more accurate or more efficient estimate of the population than other measure. The arithmetic meanor (generally referred to as mean) is claimed to be the most widely used method to describe central tendency (Dörnyei *et al.,* 2007)

$$\bar{x}= \frac{x_1+x_2+x_3....x_n}{n}$$

It can also be denoted as: $\bar{x}= \frac{\sum_{i=1}^{n} x_i}{n}$

In order to determine the mean when the frequency of the observations is provided, where f1, f2, f3, … fn is the corresponding frequencies of the observations and x1, x2, x3,…xn represents the recorded observations

$$\bar{x} = \frac{f_1x_1+f_2x_2+f_3x_3+.....f_nx_n}{f_1+f_2+f_3+.....f_n}$$

This can be expressed briefly as:

$$\bar{x}= \frac{\Sigma f_i x_i}{\Sigma f_i}$$

Short-cut method:

This method is used when the size of item is very large (deviation) d = X-A/c

Formula: $=A+1/N\sum_{i=1}^{k} f_i d_i c$

Where N = $\sum_{i=1}^{k} f_i$

A= arbitrary point

C= class interval, x_i =mid value of I^{th} class

F_i = frequency of i^{th} class

It is a best measure of comparison between two series of data (Thiagarajan "Animal husbandry statistics and computer application")

Geometric mean: A particular kind of average known as the geometric mean is calculated by multiplying the numbers together and then taking the square root (for two numbers), cube root (for three numbers), etc.

The definition of it is the product of n numbers times the nth root.

$X_{geom.} = n\sqrt{x_1.x_2.....x_n}$

Simplifying by taking logarithm on both sides

$\text{Log GM} = \log (x_1, x_2 \ldots\ldots\ldots X_n)^{1/n}$

$= 1/n (\log x_1 + \log x_2 + \ldots\ldots \log x_n)$

$= \frac{\Sigma \log x_i}{n}$

therefore $GM = \text{antilog} \frac{\Sigma \log x_i}{n}$

Harmonic mean:

The reciprocal of the average of the reciprocals of the data values is known as the harmonic mean (HM).Give better result in problem concerned with time and rate. (Thiagarajan "Animal husbandry statistics and computer application")

If $x_1, x_2, x_3, \ldots$ are the 'n' observation then harmonic mean is

$HM = n /(1/x_1+1/x_2\ldots\ldots\ldots+1/x_n) = n/\Sigma 1/x_i$

$$\sum_{i=1}^{n}. {}^{1}/_{x_i} \qquad \frac{1}{\frac{}{n}}$$

In case of frequency distribution

harmonic mean $= \frac{f_1+f_2+f_3+f_4+\ldots\ldots\ldots\ldots\ldots f_n}{f_1/x_1 + f_2/x_2 \ldots\ldots\ldots\ldots\ldots f_n/x_n}$

$= N/[\Sigma f_i/x_i]$

Where x_i =mod value of the class whose frequency is f

N = total frequency

Conclusion

Central tendency is a statistical measure provide concise yet meaningful summaries of large amounts of data. They provide a measure of a group's central value. The average can be impacted by extreme data points, making it most effective as a representation of the center of a dataset when the data follows a normal (symmetrical) distribution.

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BEYOND AVERAGES: EXPLORING THE TAPESTRY OF DATA THROUGH MEASURES OF DISPERSION

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INTRODUCTION

Central tendency fails to provide a complete picture of a set of data. In a distribution, values may sometimes be closely packed or widely scattered. To provide a comprehensive description of variability in the data, we use descriptive statistical measures known as measures of dispersion. These measures indicate the extent to which variations are spread within a distribution. When the measure of dispersion is not significant, the average value (central tendency) accurately represents the series**.**

A measure of dispersion quantifies how much items in a distribution deviate above or below the average around the central value in the data. A good measure of dispersion should be easy to understand, well-defined, easy to calculate, and amenable to algebraic treatments. Measures of dispersion are classified into two categories: absolute and relative measures of dispersion.

In absolute measures of dispersion, we calculate the Range, Quartile Deviation, Mean Deviation, Standard Deviation, and Variance. In relative measures of dispersion, we calculate the Coefficient of Range, Coefficient of Quartile Deviation, Coefficient of Mean Deviation, and Coefficient of Variance.

The Range is the simplest measure of dispersion, while Standard Deviation is the most commonly used. A measure of dispersion is defined as the deviation of individual observations around the central value of the data and indicates the degree to which numerical data tends to spread around the average value.

Characteristics of Measures of Dispersion:

1. Clearly defined definition.
2. Ease of calculation.
3. Understandability.
4. Insensitivity to extreme values.
5. Utilization of all observations.
6. Relevance to other statistical measures.
7. Independence from sampling fluctuations.

Objectives of Measures of Dispersion:

1. Assess the reliability of the average.
2. Provide an accurate portrayal of the distribution or spread of values within the dataset.
3. Utilize dispersion for subsequent statistical analyses.

4. Identify sources of variability to enable informed decision-making.

Range

- Range is the difference between highest and lowest value of the set of data. It gives the extreme values in which the data lies. Range is interpreted from its title and should be easily defined, easily calculated.
- there are other measures of dispersion, like the interquartile range (IQR), variance, and standard deviation, that provide more detailed information about the spread of the data.
- Formula for calculating **Range**:

Range = H- L

- And its relative measure calculated by:
  Coefficient of Range = H-L/H+L

Merits:

- It gives a quick sense of the spread of the data
- Identifying potential outliers or data entry errors
- Comparing the spread of different datasets

Demerits:

- It is not rigidly defined
- It is not based on all observation
- It is much affected by extreme values
- It is not useful for further statistical analysis
- It is affected by sampling fluctuations

Quartile Deviation

- Quartile deviation is the half of the inter quartile range i.e. difference between third quartile and first quartile.
- Formula for calculating **Quartile deviation**:

QD = Q3-Q1 / 2

Were,

Q3= 3/4(n+1)
Q1= (n+1)/4

- And its relative measure is calculated by:

(Q3-Q1)/(Q3+Q1)

Merits:

- It is easy to calculate and simple to understand.
- It is not affected by extreme items and openend classes.

Demerits:

- It is not well defined
- It is not based on all observations
- It is not useful for further statistical analysis
- It is affected by sampling fluctuations.

Mean Deviation

- Mean deviation is the mean of all the deviations from the average of the series (mean, median, mode)
- Formula for calculating **Mean Deviation**:
  Coefficient of mean deviation = MD/ mean

Merits

- Easy to calculate: Mean deviation is simple to calculate and understand.
- Sensitive to extreme values: Mean deviation is sensitive to extreme values, which can provide insight into the data's spread.
- Measures spread: Mean deviation measures the spread of the data, giving you an idea of how much individual data points deviate from the mean.
- Not affected by squared units: Unlike variance, mean deviation is not affected by squared units, making it easier to interpret.
- Robust: Mean deviation is a more robust measure than variance, as it is less influenced by outliers.

Demerits

- 1. Not sensitive to extreme values: IQR is not sensitive to extreme values, which can be a limitation.
- 2. Only considers 50% of data: Quartile deviation only considers the middle 50% of the data, ignoring the outer 25% on either side.
- 3. Not a comprehensive measure: IQR doesn't provide a complete picture of the data's spread, as it only considers the difference between Q3 and Q1.
- 4. Not suitable for small datasets: Quartile deviation may not be reliable for small datasets, as it requires a sufficient number of data points.
- 5. Not widely used in statistical analysis: IQR is not as widely used in statistical analysis as other measures of dispersion, such as standard deviation.

Standard deviation

- Standard deviation is the root of square of the all deviation measured from the arithmetic mean.This is the most commonly used measure of dispersion
- Standard deviations is represented by σ
- Formula for calculating **standard deviation**:

Standard Deviation $\sigma = \sum \sqrt{(xi-u)^2/n}$

Merits

- 1. Measures spread: SD measures the spread or dispersion of a dataset, giving you an idea of how much individual data points deviate from the mean.
- 2. Comparability: SD allows for comparability between datasets with different units or scales.
- 3. Normal distribution: SD is a key component in the normal distribution, which is commonly used in statistical analysis.
- 4. Confidence intervals: SD is used to construct confidence intervals, which provide a range of values within which a population parameter is likely to lie.
- 5. Hypothesis testing: SD is used in hypothesis testing to determine whether a sample is significantly different from a population or another sample.

- 6. Variability: SD measures the amount of variability in a dataset, helping you understand the consistency of the data.
- 7. Sensitivity: SD is sensitive to changes in the data, making it a useful measure for detecting differences.
- 8. Widely used: SD is a widely used and accepted measure in many fields, making it easy to communicate and compare results.
- 9. Easy to calculate: SD is relatively easy to calculate, especially with modern technology.
- 10. Building block: SD is a building block for more advanced statistical concepts, such as variance, covariance, and correlation.

Demerit

- Sensitive to extreme values: SD is affected by extreme values or outliers, which can skew the calculation and make it less representative of the data.
- Not robust: SD is not a robust measure, meaning that it can be influenced by a small number of data points that are far away from the mean.
- Assumes normality: SD assumes that the data follows a normal distribution, which is not always the case.
- Not suitable for skewed distributions: SD is not an appropriate measure for skewed distributions, as it can be misleading.
- Not a direct measure of variability: SD is a squared measure, so it's not a direct measure of variability.
- Units: SD has the same units as the data, which can make it difficult to interpret.
- Not easily interpretable: SD is not as easily interpretable as other measures, such as the interquartile range (IQR).
- Can be misleading: SD can be misleading if the data has multiple modes or clusters.

Variance

- Variance is the square of standard deviation also known as mean square deviation. It is defined as the sum of square deviations of individual observation from the mean divided by total number of observations.

- Formula for calculating **Variance**:
- Variance =(Standard deviations)^2
- **Coefficient of variation = SD/Mean**

Merits

- Sensitive to extreme values: Variance is sensitive to extreme values, which can provide insight into the data's spread.
- Measures spread: Variance measures the spread of the data, giving you an idea of how much individual data points deviate from the mean.
- Comparable: Variance allows for comparability between datasets with different units or scales.
- Additive: Variance is additive, meaning that the variance of a combination of independent variables is the sum of their individual variances.
- Foundation for other measures: Variance is used to calculate other measures of dispersion, such as standard deviation and covariance.

Demerits

- Squared units: Variance has squared units, which can make interpretation difficult.
- Not easily interpretable: Variance is not as easily interpretable as other measures, such as standard deviation.
- Sensitive to outliers: Variance is sensitive to outliers, which can skew the calculation.
- Not robust: Variance is not a robust measure, meaning that it can be influenced by a small number of data points.
- Assumes normality: Variance assumes normality, which may not always be the case.

APPLICATIONS

Assuming a case of a dog is presented with the following symptoms:

lethargy, pale mucous membranes, intolerant to exercise, and emaciation, and there is suspicion of anaemia, confirming this diagnosis may involve observing haemoglobin levels in a Complete Blood Count (CBC) over a period of 5 weeks:

Normal values: 12-18 g/dL

Weekly Observations	Hemoglobin count (g/dL)
Week 1	**2.6**
Week 2	**3.8**
Week 3	**4.6**
Week 4	**6.7**
Week 5	**9.2**

1.Range = H-L

=9.2-2.6

Range. =6.6

2.Quartile deviation (QD) = (Q3-Q1)/2

QD=2.9

3.Mean deviation = ∑|xi- u|/n

=10.28/5

Mean deviation =2.05

4.Standard deviation =∑ √(xi-u)²/n

=√27.16/5

Standard Deviation σ =2.33

5.Variance=(σ)²

= (2.33) ²

Variance =5.43

Hence, the values of different measures of dispersion are as follows:

RANGE	**6.6**
QARTILE DEVIATION	**2.9**
MEAN DEVIATION	**2.05**
STANDARD DEVIATION	**2.33**
VARIANCE	**5.43**

CONCLUSION

From the above discussion, it is concluded that measures of dispersion are well-defined, easy to understand, and easy to calculate. They are capable of algebraic calculations and are free from personal bias. The range allows us to determine the difference between the largest and smallest numbers in a set. It is also a cost-effective measure of dispersion, saving time and effort. In mean deviation, the deviation of values may be taken from any measure of central tendency. Mean deviation is useful in various fields such as economics and commerce. Standard deviation is capable of algebraic treatment and is particularly useful in statistical analysis.

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FUNCTIONS, SOURCES AND FOOD PROCESSING PRACTICES TO ENHANCE MINERAL BIOAVAILABILITY

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Abstract
Minerals are important nutrients and need to be supplied through a balanced diet. Depending upon the quantity required, they are classified as major and minor minerals. Milk, meat, whole grains, legumes, seeds and green leafy vegetables are the major source of some important minerals. While the kind of processing and cooking affect the content of minerals in diet, the bioavailability of minerals to the human body is affected by the presence or absence of some promoters and inhibitors.

Introduction
The term mineral is applied to chemical elements present in the ash of calcined tissue. Dietary minerals may be present in inorganic salts, or as part of carbon-containing organic compounds. For example, magnesium is present in chlorophyll, the pigment that makes plants green. These mineral elements are broadly divided into two classes i.e. macro and micro minerals. Macro minerals also referred to as minerals are distinguished from micro minerals by their occurrence in the body. Thus, macro minerals constitute at least 0.01% of the total body weight or occur in minimum quantity of 5 g in a 60 kg body. They are required in amounts greater than 100 mg per day. On the other hand, requirements of micro minerals vary from few milligrams to micrograms per day.

Six major minerals are required by people in gram amounts: range from 0.3 to 2.0 grams per day: Calcium, phosphorus, magnesium, sodium, potassium, chlorine. Nine trace minerals (micro minerals) are required in people in minute amounts: Iron, zinc, copper, chromium, selenium, manganese, iodine, fluorine, molybdenum (**Manay, and Shadaksharaswamy, 2008**). There are additional requirements for cobalt, but these are generally expressed in terms of the cobalt-containing B_{12}. All trace minerals are toxic at high levels.

Minerals have various functions in the body (Table 1). About 4-6 % of the human body weight consists of minerals, 4/5 of this being in the skeleton and the rest in other organs. Minerals, as salts, are constituents of bone and teeth. As ions in body fluids, minerals regulate the metabolism of many enzymes, maintain the acid-base balance and osmotic pressure, facilitate the membrane transport of essential compounds, and maintain nerve and muscular irritability.

Table 1. Minerals: Their Functions and Food Sources.

MINERALS	FUNCTION	SOURCES
Calcium	• Bone mineralization • Muscle contraction • Nerve conduction • Membrane permeability • Enzyme regulation • Blood clotting	Milk and milk products, millets- ragi, amaranth seeds, Pulses- rajmah, bengal gram, horse gram, GLVs, fish & sea food
Phosphorus	• Bone mineralization • Intracellular buffer • Component of cell membrane, nucleic acids and coenzymes • Energy metabolism	Meat, fish, poultry, egg, milk and its products, cereals, nuts and legumes
Magnesium	• Bone mineralization • Energy metabolism • DNA, RNA and protein synthesis • Electric potential • Membrane stabilization	GLVs, legumes, tea, coffee, cocoa, beans, nuts
Sodium, Potassium & Chlorine	• Electrolyte balance • Fluid balance • Acid-base balance • Signal transduction • Membrane potential • Osmotic pressure • Nutrients transport • Component of gastric and pancreatic juice	Common salt Na: milk, meats, eggs, vegetables K: fruits, vegetables, fresh meat
Iron	• Oxygen transport & storage • Electron transfer • Substrate oxidation-reduction • Detoxification of drugs • Signal controlling in neurotransmitters • Synthesis of steroid hormone & bile acids	Heme iron: meat, poultry, fish Non-heme iron: cereals, pulses, legumes, fruits and vegetables
Zinc	• Component of metalloenzymes • Transcription factor	Lean red meat, poultry, sea food, whole grain cereals, pulses, legumes, nuts, vegetable, roots
Copper	• Serves as co-factor of enzymes • Regulates gene expression • Bone formation • Integrity of connective tissue • Functioning of CNS	GLVs, nuts, legumes, dried fruits, muscles meas, shellfish especially oysters

MINERALS	FUNCTION	SOURCES
Selenium	• Antioxidant: glutathione peroxidase • Iodine metabolism	Organ meats, sea foods, eggs, cereals, mushrooms, sunflower seeds, brazil nuts, garlic
Chromium	• Glucose tolerance factor • Potentiates action of insulin	Brewer's yeast, whole grains, spices, organ meats, mushrooms, tea, cheese, prunes
Manganese	• Integral part of Metalloenzymes • Act as Enzyme activator	Whole cereals, nuts, leafy vegetables, tea
Iodine	• Biosynthesis of thyroid hormone	Sea fish, shellfish, meat, milk, eggs, cereal grains, common salt
Fluorine	• Protect from dental caries • Bone mineralization	Drinking water
Molybdenum	• Component of coenzymes: xanthine oxidase	Lentils, beans, peas, yeast, cereals, GLVs

GLV: Green leafy vegetables

ABSORPTION PROMOTERS AND INHIBITORS

All minerals in the diet are not equally absorbed. Also different compounds and the complexes of same minerals are absorbed with different degree of efficiency. Bioavailability is defined as the proportion of a nutrient in a food, diet, or dietary supplement that is absorbed and used for normal body functions. In order to become bioavailable, minerals must be absorbable and thus bioaccessible **(Henry and Massey, 2001)**. Mineral bio accessibility depends on dietary sources and the presence of inhibitors and promoters of absorption.

Mineral	Enhancer	Inhibitor
Calcium	Lactose, sugar, sugar alcohols, amino acid: lysine & arginine	Phytates, oxalates, non-fermentable fibers
Iron	Amino acid: cysteine, ascorbic acid, citric acid, fructose, sorbitol	Phytate, polyhenols, fiber, oxalate, tannins
Zinc	Amino acid: histidine & cysteine, citric acid, picolinic acid, glutathione	Phytate, oxalate, fiber, EDTA, & tannins

(Henry and Massey, 2001)

FOOD PROCESSING PRACTICES TO ENHANCE MINERAL BIOAVAILABILITY

Several traditional household food-processing and preparation methods can be used to enhance the bioavailability of micronutrients in plant-based diets. These include thermal processing, mechanical processing, soaking, fermentation, and germination/malting. These strategies aim to

increase the physicochemical accessibility of micronutrients, decrease the content of antinutrients, such as phytate, or increase the content of compounds that improve bioavailability. A combination of strategies is probably required to ensure a positive and significant effect on micronutrient adequacy.

Thermal processing

Thermal processing may improve the bioavailability of micronutrients such as iodine by destroying certain antinutritional factors (e.g., goitrogens), although whether it degrades phytate, a potent inhibitor of iron, zinc, and calcium absorption, depends on the plant species, temperature, and pH **(Hotz and Gibson, 2007)**. Boiling of tubers and blanching of green leaves induce moderate losses (i.e., 5–15%) of phytic acid.

Mechanical processing

Household pounding is used to remove the bran and/or germ from cereals, which in turn may also reduce their phytate content when it is localized in the outer aleurone layer (e.g., rice, sorghum, and wheat) or in the germ (i.e., maize). Hence, bioavailability of iron, zinc, and calcium may be enhanced, although the content of minerals and some vitamins of the milled cereals are simultaneously reduced **(Arora, 2022).**

Soaking

Soaking cereal and most legume flours (but not whole grains or seeds) in water can result in passive diffusion of water-soluble Na, K, or Mg phytate, which can then be removed by decanting the water. Reusing this water in cooking can help reduce the loss of minerals due to leaching **(Yadav et al., 2023).** The extent of the phytate reduction depends on the species, pH, and length and conditions of soaking.

Fermentation

Fermentation can induce phytate hydrolysis via the action of microbial phytase enzymes, which hydrolyze phytate to lower inositol phosphates. Such hydrolysis is important because *myo*-inositol phosphates with <5 phosphate groups (i.e., IP-1 to IP-4) do not have a negative effect on zinc absorption, and those with <3 phosphate groups do not inhibit nonheme iron absorption.

The extent of the reduction in higher inositol phosphate levels during fermentation varies; sometimes 90% or more of phytate can be removed by fermentation of maize, soy beans, sorghum, cassava, cocoyam, cowpeas, and lima beans.Low-molecular-weight organic acids (e.g., citric, malic, lactic acid) are also produced during fermentation and have the potential to enhance iron and zinc absorption via the formation of soluble ligands while simultaneously generating a low pH that optimizes the activity of endogenous phytase from cereal or legume flours.

Germination/malting

Germination/malting increases the activity of endogenous phytase activity in cereals, legumes, and oil seeds through de novo synthesis, activation of intrinsic phytase, or both. Tropical cereals such as maize and sorghum have a lower endogenous phytase activity than do rye, wheat, triticale, buckwheat, and barley. Hence, a mixture of cereal flours prepared from germinated and ungerminated cereals will promote some phytate hydrolysis when prepared as a porridge for infant and young child feeding. Certain tannins and other polyphenols in legumes (e.g., *Viciafaba*) and red sorghum may also be reduced during germination as a result of the formation of

polyphenol complexes with proteins and the gradual degradation of oligosaccharides. Such reductions in polyphenols may facilitate iron absorption.

Conclusion

An integrated approach that combines a variety of the traditional food-processing and preparation practices discussed above, including the addition of even a small amount of animal-source foods, is probably the best strategy to improve the content and bioavailability of micronutrients in plant-based diets in resource-poor settings. This is important because phytic acid is a potent inhibitor of iron absorption, even at low concentrations. Also, use of purified dietary fibers (which are free from phytates) in the diet may be beneficial as they do not adversely affect the bioavailability of minerals such as calcium from milk (Arora and Patel, 2019). Use of such a combination of strategies can help increase the bioavailability of minerals.

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MUSHROOMS: THE DELICIOUS VEGAN MEAT ALTERNATIVE

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Abstract
As the demand for healthier and more sustainable food options rises, mushrooms have emerged as an attractive alternative to traditional meat. With growing concerns over the health risks associated with high meat consumption and the environmental impact of livestock farming, mushrooms offer a promising solution. Mushrooms are low in calories, free from cholesterol, and rich in essential nutrients, including proteins, dietary fibre, vitamins, and minerals. Their unique umami flavor and fibrous texture closely resemble that of meat, making them a desirable choice for those seeking to reduce animal products. Additionally, mushroom production is more resource-efficient and environment friendly compared to meat, requiring less land, water, and energy while emitting fewer greenhouse gases. This article explores the nutritional benefits, health advantages, and environmental impacts of mushrooms as meat substitutes, highlighting their potential in addressing modern dietary and ecological challenges.

Keywords : Mushroom, Meat, Alternative, Vegan

Introduction

As the quest for healthier and more sustainable food options intensifies, mushrooms have emerged as a compelling alternative to traditional meat. With increasing awareness of the health risks associated with high meat consumption and the environmental impact of livestock farming, many consumers and food producers are turning to mushrooms as a viable substitute. Mushrooms offer a range of nutritional benefits while addressing concerns about health and sustainability. They are low in calories, free from cholesterol, and rich in essential nutrients such as proteins, dietary fibre, vitamins, and minerals (Pérez-Montes et al., 2021). Additionally, mushrooms are known for their unique umami flavor and fibrous texture, which closely resembles that of meat, making them an appealing choice for those seeking to reduce or eliminate animal products from their diets. The environmental footprint of mushroom production is notably smaller compared to that of conventional meat. Mushrooms require fewer resources such as land, water, and energy and produce lower levels of greenhouse gases. This sustainability factor, combined with their nutritional advantages, positions mushrooms as a leading candidate in the development of meat alternatives. In this article, we have explored the various aspects of mushrooms as meat substitutes, including their nutritional profile, health benefits, and environmental impact, to understand why they are increasingly seen as a healthier and more eco-friendly choice.

Mushroom vs meat: Nutritional comparison

When comparing mushrooms to traditional meat, several nutritional differences and similarities stand out. Mushrooms are valued for their low calorie and cholesterol-free profile, along with

their high content of dietary fibre, vitamins, and minerals. In contrast, meat is a rich source of high-quality protein and essential minerals, but it also contains cholesterol and generally lacks fibre (Pérez-Palacios et al., 2019). The key nutritional aspects of mushrooms and meat, highlighting their respective benefits are given in Table 1.

Table 1: Nutritional comparison of mushrooms and meat

Aspects	Meat	Mushroom
Protein Quality	Good quality protein source	Good quality protein source
Cholesterol	High cholesterol	No cholesterol
Fibre Content	Low fibre content	Good source of fibre
Vitamin B Complex	Contains vitamin B complex (but not folic acid)	Contains vitamin B complex (including folic acid)
Vitamin D	Contains Vitamin D_3	Contains Vitamin D_2 (Only vegetarian source of Vitamin D)
Minerals	High in sodium Rich in Iron, zinc, phosphorus	Low in sodium Rich in Potassium, Selenium, Copper, and Zinc
Texture & Flavor	Liked for its meaty texture	Comparable meaty texture with additional 'Umami' flavor which makes them unique &delicious

Mushrooms:

1. **Low in Calories**: Mushrooms are low in calories (about 22 calories/100g fresh white button mushrooms). This makes them an excellent choice for weight management.
2. **Rich in Nutrients**:
    - **Vitamins**: Mushrooms are high in B vitamins such as riboflavin, niacin, and pantothenic acid, essential for energy production and brain health. Mushrooms are also the only vegan source of Vitamin D.
    - **Minerals**: They are a good source of selenium, copper, and potassium, with selenium acting as a powerful antioxidant.
    - **Fibre**: Mushrooms are high in dietary fibre, aiding digestion and promoting satiety.
3. **Protein Content**: Although mushrooms do contain protein, it is relatively lower compared to meat, amounting to about 30-40% on a dry weight basis. However, their high-quality digestible protein contributes to a balanced diet.
4. **Antioxidants**: They are rich in antioxidants like ergothioneine and glutathione, which help reduce oxidative stress and lower chronic disease risk.
5. **Bioactive Compounds**: Mushrooms contain polysaccharide-protein complexes and lectins with potential immunomodulatory, antitumor, and hypotensive effects. These compounds may offer additional health benefits beyond basic nutrition.

Meat:

1. **High in Protein**: Meat provides a significant amount of high-quality protein, essential for muscle maintenance. Meats such as lean beef, chicken breast, and pork typically contain about 30-35% protein on a dry weight basis.

2. **Vitamins and Minerals**:
    - **B Vitamins**: Especially B12, crucial for nerve function and red blood cell formation.
    - **Iron**: Provides heme iron, which is more readily absorbed than plant-based iron.
    - **Zinc**: Important for immune function and cell division.
3. **Fat Content**: Meat varies in fat content; lean cuts are lower in fat, while fatty cuts contain higher saturated fat, which can impact heart health.
4. **Health Risks**: Meat often contains high levels of saturated fat and sodium, linked to cardiovascular diseases and colorectal cancer. Additionally, meat can expose consumers to foodborne pathogens like Salmonella and E. coli.

Environmental and Ethical Considerations

Mushrooms:

1. **Sustainability**: Mushrooms require fewer resources compared to livestock farming, using less water (25 litre per kg mushrooms) and land (vertical farming) while emitting fewer greenhouse gases. This makes mushroom production more sustainable.
2. **Environmental Impact**: The production of mushrooms results in lower carbon emissions compared to conventional meat. This contributes to a smaller environmental footprint.
3. **Animal Welfare**: Mushrooms provide an ethical alternative to meat, avoiding concerns related to animal cruelty and unethical practices.

Meat:

1. **Resource Intensive**: Meat production demands more land, water, and energy, and results in higher greenhouse gas emissions compared to plant farming. Livestock contributes significantly to greenhouse gas emissions: 9% CO_2, 39% methane, and 65% nitrous oxide.
2. **Environmental Harm**: The environmental impact of meat production includes global warming, water pollution, and excessive land use.
3. **Animal Welfare**: Issues related to animal cruelty and unethical practices in meat production are significant.

The Shift towards Meat Alternatives

With growing awareness of the links between diet and health, there is a rising demand for nutritious, low-sodium, and low-fat food options (Lee et al., 2020). Mushrooms have gained attention as a viable solution due to their high-quality proteins, dietary fibre, and nutraceuticals. They are ideal for formulating low-caloric functional foods and are increasingly seen as next-generation healthy food components.

Innovations in Fungal-Based Meat Alternatives

The development of fungal-based meat analogues is gaining momentum as a sustainable alternative to traditional meat. Fungi, including various mushroom species, offer high nutritional content and a rapid growth rate, making them an ideal choice for meat replacement (Wong et al., 2022). Notable species such as *Fusarium venenatum*, *Pleurotuseryngii*, and *Lentinula edodes* are being explored for their potential in creating meat substitutes.

Future Directions

The food industry is actively reformulating products to be healthier and more sustainable. While plant-based meat alternatives have gained prominence, there is a noticeable shift towards using mushrooms and fungi. These alternatives are still evolving but hold considerable promise.

Ongoing research focuses on improving the sensory qualities of these products, such as texture, juiciness, and flavor, to more closely mimic traditional meat.

Conclusion

Mushrooms present a convincing alternative to meat, offering numerous nutritional benefits and environmental advantages. They align with modern dietary trends towards healthier and more sustainable eating practices. As the demand for plant-based and fungal-based meat substitutes continues to grow, mushrooms are set to play a crucial role in shaping the future of food in sustainable manner.

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NATIONAL FISH FARMERS DAY, JULY 10th : IMPORTANCE AND THE PRESENT STATUS OF THE TECHNOLOGY DEVELOPED IN 1957

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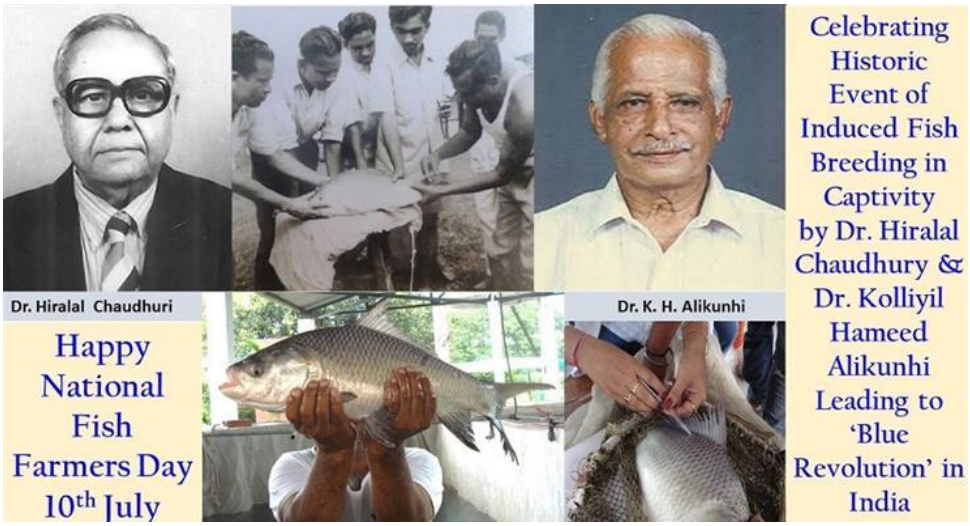
In India, National Fish Farmers day is celebrated every year on July 10th to celebrate the success of induced breeding of carps using pituitary extract by Dr Hiralal Chaudhuri in 1957. He achieved this breakthrough under the guidance of Dr K. H. Alikunhi. He is popularly known as Father of Blue Revolution in India. This success in induced breeding of fishes has led to mass scale seed production of Indian major carps and Chinese carps. The method is also applied to other cultivable freshwater, brackishwater and marine fishes. In aquaculture, the use of pituitary extract for induced breeding is known as hypophysation. This technique is still used in several parts of India like West Bengal and Tamil Nadu.



(Source: https://www.punjabnewsexpress.com/news/news/vet-varsity-acclaims-fish-farmers-contribution-on-national-fish-farmers-day-172842)

In hypophysation technique, mammalian and non-mammalian crude pituitary extract is administered to cultured fishes. In the early 60s and 70s, crude pituitary extract was widely used for induced breeding. Later, partially purified and purified fish pituitary extract were used for induced breeding of fishes. Also, availability of purified gonadotropin like human chorionic gonadotropin (HCG) in the market in 80's and 90's led to wide usage of this technique in induced breeding of fishes. A major drawback with this method is species specificity and purity of the gonadotropin extract. Also, administration of HCG induces production of antibodies which prevents physiological action of gonadotropin. To overcome this problem, fisheries scientists have started cloning of cDNAs encoding pituitary gonadotropins (FSH, follicle stimulating hormone and LH, luteinizing hormone) from different cultured fishes to understand the functions of this gonadotropins in modulating gametogenesis in fishes. The cDNA sequences of fish gonadotropins

can be accessed in NCBI Genbank database. Now, it is well understood that FSH is involved in early stages of gametogenesis and LH in later stages of gametogenesis and spawning.

Presently, the trend is use of recombinant gonadotropins for induced breeding. Several studies have demonstrated the superiority of pituitary gonadotropins for inducing vitellogenesis, final oocyte maturation and spermiation under in vitro and in vivo condition. Both mammalian and non-mammalian cell culture based systems are used to produce recombinant proteins based on the available gonadotropin cDNAs transfected to commercially available cloning vectors. Particularly, insect cell based systems are widely used for screening and evaluating recombinant gonadotropins for induced breeding and seed production. Recently, recombinant gonadotropins were successfully used to induce oocyte development in European eel (*Anguilla anguilla*) under in vitro and in vivo conditions (Jehannet et al., 2023). In captive maintained European eels, oocyte development is inhibited due to low swimming condition and other captive induced stress condition. Also, recombinant FSH and LH therapy was used to induce spawning in flathead grey mullet (*Mugil cephalus*) under captive condition (Ramos-Judez et al., 2022). In addition to the above trend, several research groups have attempted to purify gonadotropins from fish pituitary gland and understand their functions. These studies have also resulted in development of enzyme linked immunosorbent assays for FSH and LH to quantify their levels in peripheral circulating blood.

In India, there is a need to produce purified fish gonadotropins and recombinant fish gonadotropins to understand the function of follicle stimulating hormone and luteinizing hormone in different stages of gametogenesis in fish. Already, few studies have been initiated in Central Institute of Fisheries Education, Mumbai and further studies are warranted to clarify their distinct role in reproduction cycle. In this line, we have initiated collecting carp pituitary glands from West Bengal and test its efficacy for induced breeding in fishes. Further detailed studies will be undertaken in the near future to establish fish pituitary gland bank for promoting carp seed production in the state.

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THRIVING AGRICULTURE IN THE NORTH-EAST REGION OF INDIA: CURRENT STATUS, PROBLEMS, AND FUTURE OPPORTUNITIES

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Abstract
Agriculture in Northeast India faces numerous challenges, both natural and manmade, that are multi-sectoral and multidimensional. Key issues directly impacting the sector include small and fragmented landholdings, inadequate quality seeds and planting materials, imbalanced or minimal use of fertilizers, natural disasters, limited irrigation facilities, lack of mechanization, and problems with diseases and pests. Given the significance of Northeast India, this study aims to analyze agricultural development using statistical data and secondary sources from MoSPI. It provides a detailed examination of the problems and prospects in agriculture, as well as the strategies needed to address these issues and achieve a sustainable in the Northeast states.

Agricultural and allied sector Scenario of North East India

The North-East region of India consists of seven states: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura. This states area has an average population density of 159 people per square kilo meter. However, Assam, which is the largest state in this region, has a significantly higher population density of 397 people per square kilo meter. On the other hand, Arunachal Pradesh, situated in the Himalayan foothills, has a sparse population density of only 17 people per square kilo meter. The total population of the North-East is approximately 45 million, which constitutes 3.76 per cent of the country's total population. This diverse population includes various ethnic and cultural groups. The North-East region states contributed 2.73 per cent to the total national GDP during 2021-22. Between 2012 and 2022, among all the states Mizoram had the highest average growth rate of GDP at 10.09percent, followed by Tripura at 7.66 per cent. Only these two states achieved a GDP growth rate above 7 per cent. Assam and Arunachal Pradesh grew by an average of over 6 per cent per year between fiscals 2013 and 2022. Manipur, Nagaland, and Mizoram were the slowest growing states, with an average growth rate of 2-3 per cent. Approximately 88 per cent of the total geographical area of the North-East region falls under reported land use. Out of this reported area, which covers 22.5 million hectares, only 16.5 per cent is actively cultivated. Around 15 thousand square kilometres are subject to shifting cultivation, with only 4 thousand square kilometers being cultivated during a crop year, resulting in a Jhum cycle of just over three years. About 20 to 25 per cent of families, excluding those in Assam, engage in shifting cultivation, totaling around 4.40 lakh families. The cropping intensity is 1.4, leading to a gross cropped area of about 5.2 million hectares. Due to low input use and limited adoption of technology, as well as a lack of infrastructure facilities, and low irrigation intensity in this region, irrigated area covering only about 16 per cent of the gross cropped area. Fertilizer consumption is minimal, at about 9.5 kg per hectare of gross sown area, compared to the national average of 67 kg per hectare (GOI, 2017). Consequently, this entire factor led to the

productivity of food grains were below the national average in Arunachal Pradesh, Assam, Manipur, Mizoram, and Nagaland states. The productivity of pulses and oilseeds in these states is also lower than the national average.

The North-Eastern region produces high-value fruits like bananas, citrus fruits, pineapples, papayas, passion fruits, and strawberries, but fruit productivity is only 11 tons per hectare, below the national average of 15 tons per hectare in 2022-23 (GOI, 2023). Vegetable productivity is similarly low at 12 tons per hectare, compared to the national average of 18 tons per hectare. Fruit productivity has stagnated or declined over the past decades due to traditional cultivation methods, lack of commercial production, insufficient irrigation (relying mainly on rainfed conditions), minimal use of inorganic inputs, and the high diversity of fruit crops, which negatively impacts production improvement. The livestock with crops is more sustainable because they provide opportunities for rotation diversity, nutrient recycling and greater energy efficiency. Rural households owning land of more than 0.5 hectares are having 70 per cent of the livestock population (Samberg *et al*., 2016). Bovine ownership remains more equitable than land ownership, and marginal and near-landless or landless farmers have been at the forefront of the transition of the bovine economy from draught to dairying (Birthal, 2010). Naik et al., (2023) found that cattle population, crossbred cows in north east region accounted for around 27 per cent in 2019 as against the 12 per cent growth rate in 2003. Similarly, the adoption of productive/ crossbred sheep and pig populations increased from 3 to 5 per cent and 13 to 23 per cent respectively, in the study period. In 2019, about 50 per cent of the poultry population was crossbred, which has increased from 33 per cent in 2003.

Challenges in NE Indian Agriculture:

Agriculture in the North-Eastern (NE) region of India faces several challenges that hinder its productivity and growth. These challenges are:

Low Productivity:

Productivity levels of major crops in the NE states are below the national average due to factors like limited access to productivity-enhancing technologies. High flood risk and low irrigation capacity hinder the adoption of high-yielding variety (HYV) seed-fertilizer technology. During the kharif season, floods make high-yielding paddy varieties vulnerable and risky to invest in, while the dry season limits HYV use due to insufficient irrigation. However, in the Imphal valley, where irrigation is better and floods are rare, fertilizer use is higher, resulting in rice yields comparable to the national average. Additionally, livestock farmers are slow to adopt productivity-enhancing practices like crossbreeding, partly due to the high cost of fodder and poor rearing conditions for local milch animals.

Restricted Access to Irrigation Systems:

The development of irrigation facilities is crucial for improving the cultivation of high-yielding varieties (HYVs) and the use of chemical fertilizers in the region. Without such infrastructure, achieving higher yields in food crops becomes a formidable challenge. Rice, being the predominant staple food, occupies nearly 70 percent of the region's food grain area. Therefore, enhancing rice yields is closely tied to improving overall food crop productivity. Currently, the average rice yield in the region stands at 2213 kg per hectare, significantly lower than the national average of 2809 kg per hectare. Similarly, cultivating cash crops requires reliable irrigation, proper

input usage, and meticulous management, making it a distant prospect for driving agricultural development without adequate support systems.

Small and Marginal land holdings in NE region

Except for Nagaland, the agricultural landscape of the North-Eastern region is largely dominated by marginal farmers. The state of Tripura has the smallest average farm size, at 0.30 hectares. In Assam, small and marginal farmers constitute 86.2 per cent of the total farming population, while in Tripura; this figure rises to 96.32 per cent, as reported in the All India Agriculture Census for 2015-16. The primary reasons behind the declining livelihoods of farmers in the North Eastern Hill Region (NEHR) are low productivity and fragile agricultural production systems. Barah (2007) noted that the limited size of cultivable land restricts the possibility of expanding agricultural practices horizontally. Consequently, these small and marginal farmers face significant risks and uncertainties in their farming activities.

Transport and Unregulated markets:

The challenging mountainous terrain and inadequate rural road infrastructure in the North-East region (NER) complicate the transportation of agricultural goods, leading to high costs and limited market access. With a surfaced road ratio of 0.27 compared to India's 0.51 and road length per 100 sq km at 46 km versus the national average of 64 km, most farmers rely on local traders due to minimal railway access, except in Assam and Tripura. Poor agricultural marketing and impassable rural roads during the rainy season further hinder farmers' ability to reach major markets.

Traditional Farming Practices:

"Jhuming," a traditional method of producing food in the North-East region, involves clearing and burning hill slopes to plant seeds. Approximately 2 million tribal people in India practice Jhuming on about 11 million hectares of forest land, with the North-East accounting for 7.76 percent of this area. This slash-and-burn method, covering 30 percent of settled agriculture, depletes soil microorganisms and reduces fertility, leading to low productivity and resource degradation.

Lack of Mechanization

The North East region of India significantly lags in agricultural mechanization compared to states like Punjab and Haryana, which have mechanization levels of 40-45 percent. In the North East, over 86 percent of operational land holdings are less than 2 hectares, making mechanized equipment economically unviable for most farmers. The hilly terrain and poor infrastructure further hinder the use of agricultural machinery. As a result, farmers rely heavily on manual labor for ploughing, sowing, harvesting, and transportation, leading to lower productivity and higher production costs compared to other parts of India.

Uneven or Inadequate Application of Fertilizers

Centuries of continuous farming without proper soil maintenance have left Indian soils depleted and unproductive, resulting in low crop yields. Fertilizer and manure usage, crucial for soil health, are significantly below the national average in the North East. For instance, in 2004-2005, states like Nagaland, Sikkim, and Arunachal Pradesh had negligible fertilizer application, while Tripura, Assam, and Meghalaya also fell short of the 2022-23 national average of 141.5 kg/ha, highlighting the need for improved soil management and fertilizer use in the region.

Policy and Institutional Challenges:

There are several reasons why establishing large-scale industries in the region is not highly feasible, although certain parts of the region may be exceptions. One significant factor is the geographical location of the region on the nation's borders. The political and economic dynamics of frontier regions are typically intricate and not easily transparent. Investing in such areas carries considerable risks, exacerbated by location-related disadvantages and socio-economic challenges.

Government initiatives in North East regions

In the 2023-24 budget, the Ministry of Agriculture & Farmers Welfare allocated ₹11,552.35 crores for agricultural development in the Northeast, while the Department of Agricultural Research and Education (DARE) allocated ₹525 crores. The region's unique resources and trained workforce offer significant potential for boosting both regional and national economies. The government's "Look East Policy" and the ongoing ₹12,882.2 crore scheme from 2022-23 to 2025-26 by the Ministry of Development of North East Region (MDoNER) should be leveraged to enhance agriculture-centric employment and development.

Opportunities for future development of agriculture in North Eastern region

The Northeast region boasts rich biodiversity, including a vast array of medicinal and aromatic plants. Assam alone has over 5,000 crop germplasms, 240 fish species, 30% of India's bamboo resources, 43 citrus germplasms, and 23 indigenous fruits. With its diverse topography and agro-climatic conditions, the region is ideal for high-value crops, fruit production, plantation horticulture, floriculture, and medicinal plant cultivation. Sustainable growth can be driven by high-value agriculture, fish farming, and tourism, especially farm and eco-tourism. The region's soil, free from chemical-centric agriculture, offers an opportunity for an evergreen revolution, positioning NE India as a leader in organic farming. State-specific strengths include orchid cultivation in Arunachal Pradesh, mushroom cultivation in Manipur, spices in Nagaland, and off-season vegetables in Meghalaya and Arunachal Pradesh.

Collection, characterization and conservation of germplasm:

A thorough investigation of the north east region is required, as is the gathering of all the germplasm that is present there. These germplasms ought to be maintained in one location and described morphologically and molecularly. High-yielding domestic and foreign cultivars should be included in strategic breeding programmes using this material.

Promoting the diversification and intensification of crops:

Cropping pattern is dominated by foodgrains, mostly rice. When it comes to rice, monocropping has permitted the land to lie fallow for an extended amount of time, even if multiple crops (double or triple cropping) might be grown there in a given year. Because of the beneficial environment, farmers can plant vegetables (such as cauliflower, cabbage, chilli, capsicum, and potatoes) and fodder crops (like oats) and efficient organisation of the post-harvest chain is pertinent also for inducing diversification of rice centric agriculture in the plains to crops like potato and vegetables.

High value horticulture crops:

Plantations crops like tea, rubber, and bamboo, as well as fruits like bananas, pineapples, oranges, passion fruits, and papayas, as well as spices like ginger, garlic, black pepper, cardamom, and chillies, can yield substantial returns per unit of land and offer excellent investment opportunities.

The NER's agro climatic appropriateness for high-value agriculture and the area's low usage of chemical fertilisers call for the development.

Multi-storied cropping system:

Population growth limits horizontal land expansion, making vertical expansion through multistory cropping systems essential for maximizing solar energy use per unit area. Agroforestry offers significant potential to boost agricultural output and wood production without harming the environment or land. For small-scale farmers, agroforestry can increase profits while preserving the delicate ecosystem. In the North-Eastern region, advantageous agroforestry systems include Agri-Horticulture (crops + fruit trees), Homestead Agroforestry, scattered trees in tea plantations, Protein banks (Silvi-Pasture), and Aqua Forestry. Thus, agroforestry in northeastern India has substantial potential to positively impact agricultural productivity.

Creating opportunities for disguised agricultural labor:

In line with the Lewis model of labor transformation, which posits that an unlimited labor supply can be absorbed by the industrial sector, several steps can be taken to transition labor from agriculture to industry. These include improving rural infrastructure, using central funds for infrastructure projects and economic development programs to create MSMEs and service sector jobs, and utilizing grants to develop info-tech infrastructure to absorb surplus agricultural labor. Additionally, promoting small-scale agro-based, horticulture-based, and forest-based industries, developing floriculture and mushroom cultivation, and establishing marketing infrastructure with export development funds can provide alternative employment. These measures will help shift labor from low-productivity agriculture to higher-productivity industrial and service sectors, following the Lewis model.

Training to farmers/extension functionaries:

Non-availability of trained manpower is one of the major problems of the region. As horticulture requires highly skilled personnel for grafting, pruning, orchard management and also for vegetables and ornamental plants. The farmer as well as extension functionaries should be given training from time to time regarding recent advances in horticulture. The entrepreneurship should also

Conclusion

There is an urgent need for a special focus to increase productivity in agriculture and allied sector through the supply of quality planting material, capacity building for farmers, and facilitating the adoption of improved production methods. Agriculture depends on natural environment. Therefore, in the present context of rapid degradation of natural environment, efforts should be directed for meeting the needs of the present generation without compromising the needs of future generations. However, ICAR, Agricultural Universities, higher institutions related to agriculture and allied sectors, and the Department of Agriculture in the northeastern region should collaborate for the overall agricultural development of Northeast India.

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MEGA CAMPAIGN FOR PROMOTION AND APPLICATION OF NANO FERTILISERS FOR SUSTAINABLE GREEN AGRICULTURE: IFFCO INITIATIVE

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Abstract

To boost food, nutrition and environment security and to maintain the health of Mother Earth, it is important to reduce the use of chemical fertilizers like urea and DAP as much as possible, because of their very poor nutrient use efficiency (NUE) resulting in an adverse effect on the environment. Adoption of an eco-friendly crop nutrition system which could be more efficient with minimum quantity of chemical fertilizers assumes great importance. It is worth mentioning that the use of IFFCO Nano Urea Plus and Nano DAP help in reducing the use of chemical fertilizers, emissions of greenhouse gas emissions, thus can combat the adversities of climate change and ensure climate resilient green agriculture. To create greater awareness about the benefits of nano fertilizers IFFCO has initiated “Mega Campaign for Promotion of NFs Use" from July 1, 2024, which is highlighted in this paper.

Introduction

Increasing use of fertilizers is not leading to commensurate increase in crop yield. The major reason being injudicious use of urea causing nutrient imbalance in soil-plant system and mining of soils nutrient capital, thus resulting into problem of multi-nutrient deficiency. The biggest reason for the ever-increasing unbalanced use of urea in India is the huge subsidy on urea and the very low efficiency of nitrogen use (only 30-40%). This means that about 60-70% of the nitrogen that should be available to the plants after giving urea is lost through various pathways which proves harmful to the environment in the form of gas (Nitrous oxide, NO_X), water pollution in the form of nitrate (NO_3) and ammonia (NH_3). Traditional urea has also a role to play somewhere in the high incidence of pests and diseases, crop failure and the inability of the crop to bear adversity of climate change. some part through volatilization in the form of gas and reaches the atmosphere, which creates the problem of air pollution. Some part which the crop is unable to use flows down with water beyond the root zone of the plants, as a result the problem of air, soil and water pollution arises. Like urea, only 15-20% of the phosphorus in DAP is used by the crop. The remaining amount gets fixed in the soil, which the crop plants cannot use. Thus, the health of the soil is deteriorating due to excessive use of urea and DAP. Unnecessarily, increasing use of urea and DAP is not only polluting the air, soil and water but also increasing the cost of farming and causing climate change and a bad effect on humans, animals, birds and biodiversity, due to which the uncertainty of farming is increasing. Apart from this, a major disadvantage of the unnecessary increasing use of urea and DAP is that the more these fertilizers are used, the more the subsidy burden on the government will increase. On the other hand, nano fertilizers have many

advantages due to their unique characteristics, which are easily seen in the form of reduction of soil, water and air pollution, increase in quality yield with reduced dose of conventional fertilizers. NFs help reducing incidence of pests and diseases, weed infestation and other benefits like ease of transportation and storage.

On 15 August 2019, Prime Minister Modi appealed to the farmers of the country from the Red Fort to reduce the use of chemical fertilizers. The Prime Minister had said that to maintain the health of Mother Earth, it is important that we reduce the use of chemical fertilizers.

Nanofertilisers: IFFCO Initiatives

As mentioned earlier, conventional fertilizers are not sustainable for multiple reasons, including high delivery and usage inefficiency, considerable energy, and water inputs with adverse impact on the agroecosystem. Achieving and maintaining optimal food security is a global task that initiates agricultural approaches to be revolutionized effectively on time, as adversities in climate change, population growth, and loss of arable land may increase. Recent approaches based on nanotechnology improve *in vivo* nutrient delivery to ensure the distribution of nutrients precisely, as nanoengineered particles improve crop growth and productivity. The major task may be to develop novel and efficient nutrient uses in agriculture with nutrient use efficiency (NUE) to acquire optimal crop yield with ecological biodiversity, sustainable agricultural production, and agricultural socio-economy.

To address these issues, the world's largest Cooperative (Indian Farmers Fertiliser Cooperative Limited; IFFCO) established Nano Biotechnology Research Centre (NBRC) at its parent unit, Kalol, Gujarat and took the lead to invent 3 Nano fertilizers in liquid form viz. Nano Nitrogen, Nano Zinc and Nano Copper. completely based on indigenous technology. (NFs). These products made of nano structure provide effective nutrition to the plants. IFFCO started large scale on-station and on-farm trials for testing their efficacy from 2019. The benefits of IFFCO NFs have been well documented (Kumar et al., 2021; Singh, 2022; Kashyap, 2023; Upadhyay et al., 2023; Tiwari and Kumar, 2023) which established that IFFCO NFs can curb the increased use of conventional fertilizers in an environmentally friendly way. Based on these results, IFFCO has given the whole world an excellent alternative to traditional urea and DAP fertilizers as Nano Urea Liquid and Nano DAP Liquid.

IFFCO started commercial production of the world's first indigenous Nano Urea (Liquid) based on nano technology in 2019 in consonance with the need of the day to reduce the use of conventional fertilizers like urea and DAP as much as possible and promote use of enhanced efficiency nano fertilizers (Nano Urea Plus and Nano DAP) developed by IFFCO as a compliment to climate resilient agricultural practices. Nanofertilizers are capable of reducing the use of urea and DAP fertilizers up to 50%. Our future food, nutrition and environment security should be maintained in an eco-friendly way by adopting IFFCO's Nanofertilizers and Sagarika as balanced crop nutrition solution. IFFCO Nanofertilizers have the potential to boost production of agricultural crops due to multiple benefits; increased nutrient use efficiency, reduced use of chemical fertilizers, enhanced photosynthesis and metabolic functions, increased plant resistance to abiotic and biotic stresses, weed infestation, lodging etc.

After development of Nano Urea in 2019, it is worth mentioning that as per the next phase IFFCO's research advancement and feedback of the farmers/scientists, Nano Urea Plus (20% N

w/v) as a breakthrough product has been launched recently by IFFCO. The new version Nano Urea Plus (Liquid) is much more efficient than the previous Nano Urea Liquid. Farmers have provided insight that higher concentration of nitrogen will prove better for their crops. The new version of Nano urea Plus is a chlorophyll charger and yield booster and help in climate-smart farming.

With the use of Nano Urea Plus (Liquid) and Nano DAP (Liquid), the quantity of conventional urea and DAP can be reduced up to 50 per cent. Use of IFFCO Nano Urea Plus and Nano DAP will help in reducing greenhouse gas emissions, which can combat the adversities of climate change and ensure climate resilient green agriculture. Objectives behind development of innovative NFs are shown in **Figure 1**.

Figure 1. Objectives behind development of innovative NFs

IFFCO has already started production of nano urea plus at Kalol in Gujarat and Phulpur and Aonla in Uttar Pradesh with total production capacity of 150 million bottles. Three more upcoming plants at Deoghar (Jharkhand); Bengaluru (Karnataka) will ramp up the overall production capacity of Nano Urea Plus Liquid to 340 million bottles (500 ml each) by 2027. The current annual production capacity of IFFCO Nano DAP (8-16-0) at Kalol (Gujarat) is 40 million bottles per annum, which will be 120 million bottles by FY 2025 with upcoming plants at Kandla (Gujarat) and Paradeep (Orissa). Farmers are already using Nano Urea Plus Liquid and Nano DAP Liquid in their crops. Consolidated consumption of 75 million bottles (500 ml each) of IFFCO Nano Urea (Liquid) and 4.5 million bottles of Nano DAP (Liquid) has been achieved till 2023-24.

IFFCO's Nano Urea already reached to more than 34 countries viz. Nepal, Suriname, Mexico, Kenya, Sri Lanka, Uzbekistan, Malaysia, Brazil, Kuwait, Philippines, Mauritius, Zambia, Denmark, Jordan, Canada, Malawi, Nigeria, Costa Rica, Myanmar, USA, Canada, South Africa etc.

NFs like Nano NPK, Nano Zinc, Nano Copper, Nano Boron, Nano Sulphur etc. are also in pipeline so as to provide complete basket of NFs for balanced and efficient plant nutrition.

Benefits of Nanofertilisers over Conventional Fertilizers

Fertilizers based on nanotechnology have the potential to outperform conventional fertilizers. If mineral nutrients are applied to crops in the form of NFs, they have the potential to provide many

benefits to make crop production more environmentally friendly and sustainable. The advantages of NFs are summarized below:

1) Offer superiority over conventional fertilizers due to comparatively high solubility and dispersibility.
2) Increase bioavailability of nutrients due to small size, high specific surface area and high reactivity.
3) Being applied in smaller quantities due to significantly lower nutrient losses by arresting volatilization, leaching, eutrophication, emissions etc are resulting high nutrient use efficiency (NUE) unlike synthetic fertilizers which are applied in bulk resulting in poor NUE.
4) Ensure significantly higher absorption due to free passage through nano-sized pores and molecular transporters as well as root exudates and also through various ion channels that lead to higher nutrient absorption by crop plants. Within the plant, nanoparticles can pass through plasmodesmata resulting in effective delivery of nutrients to sink sites.
5) Provide nutrients to the plants gradually in a controlled manner unlike the rapid and spontaneous release of nutrients from chemical fertilizers.
6) Ensure high efficiency of nutrient absorption matching the crop's absorption pattern in a controlled manner by slow and targeted efficient release. For example, nutrients can be released up to 20-30 days with slow-release properties. Research has shown that NFs release nutrients 12 times slower than conventional fertilizers, and they can substantially enhance crop yields and quality traits.
7) Prevent undesirable nutrient losses to soil, water and air through better uptake and assimilation by crops, and avoid nutrient interactions with soil, microorganisms, water and air that increase NUE and reduce the cost of environmental protection.
8) Avoid premature contact with soil and water due to the thin coating of nanoparticles, leading to negligible nutrient losses. These become available as soon as the plant is in a position to internalize the released nutrients.
9) Provide more efficient nutrient absorption and utilization and less risk of environmental pollution due to significantly reduced losses through leaching and volatilization.
10) Affect plant metabolic activities to varying degrees and have the ability to mobilize basic nutrients in the rhizosphere due to their unique properties.
11) Being applied through foliar spray, minimizes nutrient grabbing by weeds and in turn minimizes weed infestation.
12) Help crop plants fight various biotic and abiotic stresses by providing balanced nutrition.
13) Reduce excessive accumulation of salt in the soil as these are required in small quantities.
14) Useful for reducing chronic moisture retention problem in arid soils and increasing crop production by increasing nutrient availability in the rhizosphere.
15) Being required in small quantities, transportation and field application costs are reduced.

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 ecofriendly 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 Nanofertilizers" 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%. The main objectives of the Project are being given below.

1. To reduce the dependence on chemical fertilizers by promoting use of NFs and promote use of NFs to ensure sustainable food, nutrition and environment security.
2. To establish 200 model nano villages/clusters covering 800 villages where farmers will get 25 percent subsidy on the maximum retail price (MRP) of Nano Urea Plus, Nano DAP and Sagarika fertilizers. These clusters have been identified based on the sale of urea to launch its nano products and drone spraying initiative. The first phase, starting in the current *Kharif* season (2024), aims to cover a total of 8 lakh acres in the next few years.
3. To encourage the use of modern application techniques (Drone) for which IFFCO will provide a grant of Rs 100 per acre to drone entrepreneurs, enabling farmers to access low-cost spraying services.
4. To conduct 1,270 demos of Nano DAP (liquid) in 413 districts and 200 trials of Nano Urea Plus (liquid) in 100 districts.
5. To produce 4 crore Nano Urea Plus and 2 crore Nano DAP bottles in 2024-25 to ensure their availability in every village through its robust marketing network.

Modus Operandi

1. 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.
2. 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).
3. 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. The benefits of Nano Urea Plus and Nano DAP and Sagarika are elucidated in **Table 1** and **2**, respectively**.**
4. 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. A view of the IFFCO Drone activity is displayed in **Picture 1**.
5. 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 Centers.
6. The timeline of this project will be 3 years.
7. For better communication and awareness about this project, Nano village cluster should be near to the active sales point (IFFCO FSC/ IFFCO Bazar etc).
8. Nano village cluster should be selected from potential belt of major crop of the state.

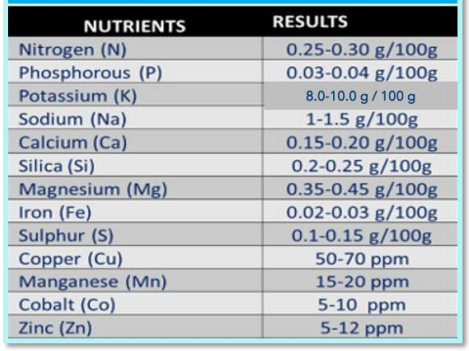
9. In each nano village cluster, there will be minimum one Village Coordinator and he should have basic knowledge of computer and agriculture.
10. Village Coordinator will have to do benchmark survey as per below line of action.
    - *Farmer Profile*: Name, mobile number, Aadhaar number, address, landholding detail, family details, name of village.
    - *Farmer's Area Soil Profile*: Soil testing date, pH, EC, Orgaic Carbon, N, P and K content.
    - *Crops*: Farmer wise detail of cropping pattern as per *Kharif*, *Rabi*and *Zaid* Season.
    - *Economics*: Cost incurred in procurement of conventional Urea, NPK, DAP and other costs before the start of project.
    - *Yield Calculation*: Crop wise per acre yield of the Agri.Produce before and after the commencement of project
11. A web portal has been developed for effective monitoring of this project.
12. The field officers of the district will increase awareness about the benefits of the use of nano fertilizers in different crops in the surrounding villages of cluster for better utilization of this project. It will be helpful in faster adoption of nano fertilizers.
13. Application flow of this project is given hereunder:
    a. On purchase of Nano Urea, Nano DAP and Sagarika by the farmer from the identified mapped retail point, three text messages will be generated, which will be sent to the village coordinator, Drone Didi/ Drone entrepreneur and the farmers for aligning the spray schedule within 2 days of purchase by the Village Coordinator and Drone Didi/Drone entrepreneur.
    b. As soon as the message of purchase of these materials will be received by drone entrepreneur and village coordinator, they will contact the concerned farmer and will arrange the spray.
    c. The subsidy to retail point and drone entrepreneur will be paid on weekly basis after confirmation by IFFCO Field officer. Relevant provisions in the system will be generated by the IFFCO IT team.
    d. To ensure the sprays, village coordinator will continuously visit in the field and will remain in close coordination with IFFCO staff.
    e. When the crop will be harvested, the reduction in the use of conventionalfertilizer and increase in the yield will be entered by the village coordinator in the IT system.
    f. Provision for uploading the images and videos will be created in the IT System which will support in cross verifying the sprays of nano fertilizers in the field.

Table 1. Benefits of Nano Urea Plus and Nano DAP

Nano fertilisers	Benefits
Nano Urea Plus Liquid (20.0% N w/v)	Reduce nutrient losses from volatilization, leaching, denitrification and microbial immobilisation leading to air, soil and water pollution. Fulfil crop nitrogen requirement, increases leaf chlorophyl, photosynthesis, root and plant growth, number of effective tillers and branches, and crop yields, reduce requirement of conventional urea up to 50 %

Nano fertilisers	Benefits
	ensuring high NUE. enhance farmer's income by increasing crop productivity at reduced rate of urea application by increasing NUE thus reduce input cost, help conserve soil, air and water quality, protect environment, reduce transportation cost.
Nano DAP Liquid) (8.0% N and 16.0% P_2O_5 w/v) 	Nutrient use efficiency of conventional DAP fertilizer is very low due to P fixation, runoff, eutrophication and negative nutrient interaction. Since Nano DAP is applied as seed/treatment and foliar spray in much less quantity, all these problems are avoided. Nano particles of Nano DAP are much smaller in size and designed to penetrate plant tissues and deliver nutrients directly to cells slowly for a long period. Fulfil crops N and P requirements, increases leaf chlorophyl, photosynthesis, root growth of seedlings and the plants, increase plant growth, number of effective tillers and branches, and thus crop yields with 50% reduction in requirement of conventional DAP ensuring high NUE.

Table 2. Benefits of Sagarika Liquid

Sagarika Liquid	
 	Seaweed extracts with bio-stimulants and stress-resistant effects, boost crop growth and mitigate extreme weather adversities, improve soil health, contains inherent nutrients, vitamins, plant growth hormones like auxin, cytokinin and gibberellins, betaines and mannitol, etc. works as a metabolic bio-enhancer, stimulates internal growth and development processes in plants, enhances physiological efficiency of crops leading to more nutrient uptake from soil, improves quality - better shape, size, uniformity, color and taste of fruits, enhances stress tolerance ability of crops and resistance against pests and diseases, promotes nutrients absorption (N, P, K, Ca, Mg, Zn, Fe etc.) by plants, naturally degradable and environmentally friendly and important component of organic fertilizers.

NUTRIENTS	RESULTS
Nitrogen (N)	0.25-0.30 g/100g
Phosphorous (P)	0.03-0.04 g/100g
Potassium (K)	8.0-10.0 g / 100 g
Sodium (Na)	1-1.5 g/100g
Calcium (Ca)	0.15-0.20 g/100g
Silica (Si)	0.2-0.25 g/100g
Magnesium (Mg)	0.35-0.45 g/100g
Iron (Fe)	0.02-0.03 g/100g
Sulphur (S)	0.1-0.15 g/100g
Copper (Cu)	50-70 ppm
Manganese (Mn)	15-20 ppm
Cobalt (Co)	5-10 ppm
Zinc (Zn)	5-12 ppm

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Picture 1. IFFCO's Drone Didi Initiative

The crop performance and the productivity in the Model Nano villages of the Project will be assessed and farmers will be convinced to use IFFCO Nanofertilizers and Sagarika on the principle of **"Seeing and Believing"** about the impact of these fertilizers. **"Crop Harvest Day"** will be organised to tell the success story based on yield, produce quality and other benefits like crop resistance to abiotic and biotic stresses, infestation of weeds, lodging etc. The help of *Krishi Vigyan Kendra,* State Agricultural University and other research institutes will be taken in these tests and the Government of India itself will monitor it.

To harness the benefit, application of Nano DAP a broad agro-climatic zone wise demonstration cum awareness campaign has been chalked out. IFFCO in collaboration with ICAR-Krishi Vigyan Kendra (KVKs) and Department of Fertilisers (DoF), Ministry of Chemicals & Fertilisers, Govt. of

India has embarked upon multiple crop and location specific Nano DAP (Liquid) demonstrations initiating from *Kharif* 2024**.**

From *Kharif* 2024, total 1270 targeted demonstrations areas planned across 27 states/UTs and 15 agroclimatic regions. 1293 demonstrations have been tentatively planned in **1092** villages of 415 districts. More than 411 ICAR-KVKs would be monitoring and participating in this demonstration on crops such as Paddy, Maize, Cotton, Groundnut, Chili, Soyabean, Red Gram, Black Gram, Sugarcane, Cabbage, Cucumber, Cauliflower, Onion, Brinjal, Okra, Tomato, Apple etc. Spraying campaigns would be organized on these demonstration sites to showcase proper spraying options for deriving maximum benefit from Nano DAP application.

IFFCO has planned to provide 2500 agricultural drones to the farmers for spraying nano fertilizers. By now, 300 IFFCO 'Namo Drone Didis'/Drone entrepreneurs have been created. Apart from this, other types of sprayers have also been made available, through which farmers will be able to easily spray nano fertilizers in their fields. IFFCO has contracted with 17 institutions to spray by drone on a total area of 255 lakh acres of the farmers' fields. An incentive of Rs 100 per acre will also be given by IFFCO on each spray.

Under this Mega Campaign, IFFCO has also planned publicity, field testing, training of the secretaries of cooperative societies in all the districts of the country. Under this campaign, 6 crore bottles of nano fertilizers (Nano Urea Plus, Nano DAP and Sagarika) are to be made available, which will be distributed through IFFCO's 36,000-member Cooperative Societies and IFFCO Sale Centres.

The IFFCO has planned to conduct thousands of demonstrations to convince about the benefits of foliar spray of Nano Urea Plus, Nano DAP and Sagarika on crops of 2000 acres on each and every field of the farmers of 100 cluster villages of this project spread in 100 districts across the country. The move may help the government to reduce the sale of chemical fertilizers and promote sustainable agricultural practices as the use of granular urea bags is increasing despite several measures such as neem coated urea, reduction in quantity in each bag and the introduction of PM-PRANAM scheme. With increased use of Nano urea Plus and Nano DAP the country would be self sufficient in respect of conventional urea and DAP ensuring relief from the import of these fertilizers thus also saving huge money being spent by the Government towards subsidy.

Summary
Efficient use of nutrients is of vital importance to maintain and boost food and nutrition, however, there are challenges with the increased use of nutrients as chemical fertilisers because of poor nutrient use efficiency (NUE) and associated environmental problem. Though the consumption of chemical fertilizers particularly urea and DAP consistently increased but increasing consumption is not leading to commensurate increase in crop yield. The imbalanced use of urea is leading to distortion in NPK use ratio and mining of soils nutrient capital leading to multi-nutrient deficiency. Low nutrient use efficiencies of Nitrogen (30-40%), Phosphorus (15-20%), and Micronutrients (2-5%) denote that the remaining quantity of nutrients are creating risk to environment, soil and crop health and risk to human and animal health. The NUE of chemical fertilisers during last few decades failed to increase to desired extent even with best fertiliser management practices. Introduction of several enhanced efficiency specialty fertilisers in Indian market is a right intervention at a right time. IFFCO has played a pivotal role in revolutionising the fertiliser sector

by researching, developing and promoting the use of specialty fertilisers and innovative enhanced efficiency Nanofertilizers to reduce the use of chemical fertilizers which is in consonance with the Prime Minister's appeal to farmers to gradually reduce use of chemical fertilisers to save the health of our mother earth. The IFFCO Mega Campaign to promote use of Nanofertilizers and Sagarika will be game changer by convincing the farmers about the benefits of foliar spray of Nano Urea Plus, Nano DAP and Sagarika through thousands of demonstrations spread in 100 districts across the country on entire crops of 2000 acres of 100 cluster villages of this project.

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REVOLUTIONIZING AQUACULTURE: THE POWER OF ORGANIC ACIDS AS FEED ADDITIVES

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ABSTRACT

Antibiotics are frequently used in the diets of cultured aquatic animals, either to prevent infectious illnesses or to enhance growth. Antibiotics used prophylactically have come under criticism in recent years, and as a result, many nations have banned their use in animal husbandry. It is essential to assess alternatives in light of the present limitations on the use of antibiotics. An alternative that could be used in aquafeeds instead of antibiotic growth promoters is organic acids and/or their corresponding salts. Recent years have seen a significant increase in both commercial interest and study into the use of dietary organic acids in aquaculture. Several studies have shown that certain organic acids can improve fish health and growth performance distinctly. However, there has been reports of contradictory outcomes, which appear to rely on the species of aquatic animals, the type and quantities of organic acids, and the culture conditions adopted. This article aims to address the increasing customer demand for seafood products free of antibiotics while also promoting the sustainability of aquaculture production worldwide by offering a competitive substitute for hazardous drugs.

INTRODUCTION

The demand for aquatic animal products is higher worldwide than that of beef, pork, and poultry products, making them an essential part of the human diet. Because it is a rich source of readily digested high-quality proteins, vital fats (such long-chain omega-3 fatty acids), vitamins (D, A, and B), and minerals, fish stands out as one of the best food sources for humans. Aquaculture models currently utilize semi-intensive and intense farming techniques instead of extensive farming systems due to the advancements in modern aquaculture.

Modern aquaculture is expanding quickly due to an array of reasons such as the intensification of culture methods and the growing usage of formulated aquafeeds. One of the most restricting issues facing the aquaculture industry as a result of the increase of farming operations is disease outbreaks.

The development of infectious diseases brought on by different pathogens severely limits the sustainability and scalability of the aquaculture business globally and results in huge financial losses for farmers. Since the discovery of antibiotics and its potential to promote growth and combat disease, the aquaculture sector has frequently employed large doses of antibiotics to prevent and/or control infectious diseases caused by bacterial pathogens. The broad use of a wide range of antibiotics in the aquaculture sector, both as growth-promoting and medicinal agents, has raised the possibility of negative consequences on the aquatic environment, human and animal health. It has been established that a number of bacterial infections linked to fish diseases have developed antibiotic resistance. Due to the potential for antibiotic residue to bioaccumulate in consumer-ready aquaculture products, the widespread use of antibiotics in aquaculture could

be harmful to public health. Furthermore, studies on farmed fish have demonstrated that prolonged antibiotic use might eventually cause resistant bacterial strains to arise, decreasing the effectiveness of subsequent antibiotics; excessive use can even adversely impair the growth and general health of fishes.

Antibiotics are no longer used in animal feed formulations due to public awareness of the prophylactic use of these drugs, which may transfer immunity from pathogenic bacterial species to humans. Therefore, it is essential for the global aquaculture industry to create efficient nonantibiotic chemicals as a substitute for antibiotics to manage infectious diseases and improve growth performance.

Recently, aquaculture researchers are becoming more interested in short-chain organic acids and their salts or combinations, also referred to as acidifiers, as they present a possible substitute for antibiotic growth promotants (AGP).

WHAT ARE ORGANIC ACIDS?

Compounds that include one or more carboxyl groups are called organic acids. These include saturated straight-chain monocarboxylic acids (C1–C18) and the derivatives of these acids, which have a general molecular structure of R–COOH, where R is the monovalent functional group. Examples of these include unsaturated (cinnamic, sorbic), hydroxylic (citric, lactic), phenolic (benzoic, cinnamic, salicylic), and multi-carboxylic (azelaic, citric, succinic). These acids are also known as weak carboxylic acids, volatile fatty acids, or short-chain fatty acids.

PRODUCTION OF ORGANIC ACIDS

Different bacterial species ferment carbohydrates by microbial processes under distinct metabolic circumstances to create organic acids. Anaerobic microbial communities in the large intestine of humans and animals also produce substantial amounts of some smaller molecular weight organic acids, such as butyric, propionic, and acetic acids. Numerous short-chain organic acids (C1–C7) are found in plants and animal tissues as regular components. Nonetheless, the majority of organic acids used in the food and feed industries are made synthetically. Organic acids can also combine with potassium (K), sodium (Na), calcium (Ca), etc. to generate single or double salts of their acid.

ORGANIC ACIDS AS FEED ADDITVE

For centuries, weak lipophilic organic acids and their salts have been utilized as food and beverage preservatives, and they are categorized as "generally regarded as safe" (GRAS) chemicals. The EU laws list them as acceptable feed additives for use in the production of food animals. In place of antibiotics, organic acids, their salts, or mixtures of them have been effectively utilized in animal diets. Even while dietary organic acids and their salts have been thoroughly investigated in a wide range of terrestrial animals, studies on aquatic creatures have only become more intense in the past ten years.

A viable substitute for enhancing animal health and performance is an acidifier. Acidifiers can also enhance feed performance; they can boost fish growth, feed utilization, and disease resistance; they can extend the shelf life of pellets. They also enhance growth performance by increasing food consumption, making the diet more palatable, facilitating a more effective conversion of food to live weight because there is less competition from bacteria for nutrients; or they can enhance enzymatic activity because the diet is less acidic, which lowers stomach pH.

MODE OF ACTION AND EFFECTS OF DIETARY ORGANIC ACIDS

Antimicrobial properties:

Most bacterial species have specific pH requirements for growth and cannot survive in extremely acidic environments (pH < 4.5). By releasing hydrogen ions into the environment, organic acids can directly lower pH levels, which can inhibit the growth and spread of bacteria that are sensitive to acid, so acting as an antimicrobial agent against microorganisms.

Influence on gastrointestinal microbiota:

Numerous research investigations have indicated that adding organic acids, their salts, and/or combinations to aqua diets can affect the bacterial ecology in aquatic animals' gastrointestinal tracts. It has been demonstrated that adding organic acids to a diet high in fish and shrimp can lower the number of potentially harmful bacteria, such Vibrio spp., in the intestinal tract. The growth performance, food consumption, immunological response, and disease resistance of cultured aquatic animals can all be significantly impacted by changes in the population and makeup of the gut microbiota. For further insight into the effects of dietary organic acids as mediated by modifications in gut microbiota, more targeted study is required.

Enhanced nutrient availability

In general, adding organic acids to aquafeeds has improved the digestion of nutrients.

They (i) lower stomach pH, which increases pepsin activation; (ii) lowers diet and intestinal pH, which might enhance mineral solubilization; (iii) act as chelating agents, binding different cations in the intestine to increase mineral absorption; or (iv) prevent harmful microbes from colonizing the intestine and using nutrients intended for the host animal. Organic acids and their salts have a growth-promoting effect on animals mostly because of what they do to the animal's gastrointestinal system and feed.

Effects of organic acids in aquatic feeds

It has been documented that feed palatability in aquatic animals is impacted by organic acids. In addition, Xie et al. (2003) found that food lactic, propionic, and citric acids positively stimulated the feeding behaviors of juvenile Nile tilapia, whereas dietary acetic and propionic acids had repelling effects. Propionate and butyrate salts, added to a commercial shrimp diet at a rate of 2 g kg-1, acted as feed attractants and significantly increased feed intake, based on a study conducted with Pacific white shrimp. The study included different Na salts of organic acids, such as formate, acetate, propionate, lactate, butyrate, and citrate (Silva et al. 2013). Some of the documented differences in growth performance in aquatic animals may have been caused by altered feed palatability brought on by dietary organic acid supplementation. Thus, further investigation is required to ascertain the appropriate amount of organic acids to incorporate into diets that are organoleptically pleasing and will have a good impact on aquatic animals' feed intake and growth performance.

Organic acids as functional feed additives in aquafeeds

Organic acids and their salts provide benefits beyond nutrition, including disease prevention or health promotion, and are regarded as functional feed additives. It is widely known that they are used in animal feed for terrestrial animals to prevent bacterial infections and to improve animal health. The most widely used organic acids, especially butyric, propionic, acetic, and formic acids,

have been demonstrated to inhibit the growth of a number of marine pathogenic *Vibrionaceae*, including *Vibrio parahaemolyticus*, *Vibrio harveyi*, and *Vibrio campbellii*, in vitro. However, the effectiveness of these acids varies depending on the type, pH, and dosage used. According to research findings, organic acids can be used in commercial aquaculture as a good substitute for hazardous antibiotics. In the aquaculture sector, dietary organic acids can be part of a sustainable fish and shrimp health management program.

Strategies to enhance efficacy of organic acids in aquafeeds

There are three main obstacles to overcome when using organic acids in aquafeeds: corrosiveness, leaching and dissociation of some organic acid in more alkaline condition. The majority of free organic acids are very corrosive, some are soluble in water easily, and organic acids lose their effectiveness in an alkaline environment. The corrosiveness of free organic acids can be minimized or avoided by converting them into their natural salts, such as potassium, sodium, and calcium salts; the effectiveness of an organic acid can be maintained even when a portion of it is in its salt form. A new class of organic acids known as coated or microencapsulated organic acids has been developed to improve the efficacy of dietary organic acids. In addition to being more convenient to use and removing corrosiveness, encapsulation will prevent leaching of the soluble organic acids. For aquatic creatures, this is crucial, particularly for slow feeders like shrimp who masticate feed pellets before ingesting them.

CONCLUSION

The commercial application of organic acids in aquafeeds to improve growth performance and manage illness is currently of great interest. Numerous studies have demonstrated that organic acids, their salts, or combinations thereof can enhance aquatic animals' development, feed utilization, gut health, and resistance to disease. Though most studies have shown an improvement in the amount of nutrients available in diets supplemented with organic acids, inconsistent results have been reported regarding the growth-promoting effects. These seem to vary depending on the type and dosage of organic acids tested as well as the aquatic animal species. The road to integrating dietary organic acids as part of a routine disease management program in any aquaculture farm is expected to be a lengthy one, but essential given the large diversity of aquatic animal species being farmed and under different cultural circumstances.

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OYSTER MUSHROOM FARMING FOR BEGINNERS

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Abstract

Oyster mushroom commonly known as "Dhingri mushroom" in India is a subtropical mushroom which is suitable for cultivation in areas with warm summers. The name Oyster was designated to it because of the shape of fruiting bodies that resembles the oyster present in sea. Scientifically oyster mushroom is known as "*Pleurotus* sp." which in Greek means "anything which is formed laterally". Different species of oyster mushroom are available for cultivation based upon different colours of the fruiting bodies. Cultivation of Oyster mushroom is best example of sustainable productivity which is ecological, profitable as well as economical. Cultivation of Oyster mushroom is beneficial for small scale farmers to start with a small unit for oyster mushroom cultivation. Oyster mushroom cultivation is the best example of low-cost input farming area which is both economical as well as ecological. In terms of nutrition value, oyster mushrooms are rich in vitamins and proteins with negligible to low fat content and having about 90 per cent of water content. In comparison to button mushroom, oyster mushroom is similar in terms of nutritional value although Zinc content was found more in oyster mushroom which is a micronutrient that is good for immune system and eye health.

Introduction

Oyster mushroom farming is an easy setup farming venture which requires a minimum cost in comparison to other farming systems. In spite of harvesting of mushroom fruiting bodies, the left out mushroom compost can be used for other activities in farming system like as a feed for vermicomposting unit, can be used as a compost after proper degradation, also be used as casing material and have been reported to be used for disease management, myco-remediation and biodegradation.

If anyone wants to set up a small unit for oyster mushroom farming, these steps should be followed diligently:

Infrastructure: Unlike other small scale faming businesses, oyster mushroom farming doesn't require a large infrastructure. With a concentre small room having proper ventilation will serve the purpose. Also, oyster mushroom faming can be carried out in open conditions with formation of a small temporary room with help of wood logs/bamboo and grass. In Punjab conditions, the best time for cultivation of oyster mushroom is from March onwards to June.

Inputs required: In terms of raw material which is required for oyster mushroom cultivation is cost effective. The substrate on which oyster mushroom is cultivated generally involves the waste material of agriculture crops like wheat straw, paddy straw, maize cobs, sugarcane bagasse and cotton waste. Since, oyster mushroom is a wood rotting fungus is can easily grow on any material which can be easily grown on any material rich in hemicellulose, lignin and cellulose.

Procedure to be followed : The process of oyster mushroom cultivation is simple which involves following steps:

1. Substrate preparation
2. Filling of bags
3. Spawning
4. Incubation and after care
5. Harvesting, packaging and marketing
6. Post harvest preparations

Substrate preparation : Based on the cost and availability of the substrate, a particular substrate is selected among different substrates like wheat straw, paddy straw, sugarcane waste etc. The substrate should be finely chopped into small pieces for better handling and better spread of mycelium of fungus. The finely chopped substrate is the sterilized so that pathogenic bacteria and fungi cannot grown over the substrate. Method of sterilization used is based on the cost. For small cost, hot water sterilization is carried out by dipping the substrate in hot water at 65-70^{o}C for 1 hour followed by its drying in shade. For chemical sterilization which involves a cost but is most effective method of sterilization. In chemical sterilization method, solution of carbendazim (Bavistin),a fungicide @ 7.5 g in combination with formalin @ 125 ml in 100 litres of water is prepared and 12 kg of substrate is dipped into this solution. The substrate after dipping in solution is covered with polythene for 16-18 hours followed by draining of excess water.

Filling of bags : After preparation of substrate followed by its proper sterilization, the straw is shade dried to remove excess of moisture. The polypropylene bags of size 60x45 cm of thickness 125-150 gauze are used for filling of the substrate. Theses bags are high temperature tolerant and are easily available in the market at low cost. Also, normal polythene bags can be used for substrate filling but polypropylene bags will provide better results. The substrate is filled in the bags tightly.

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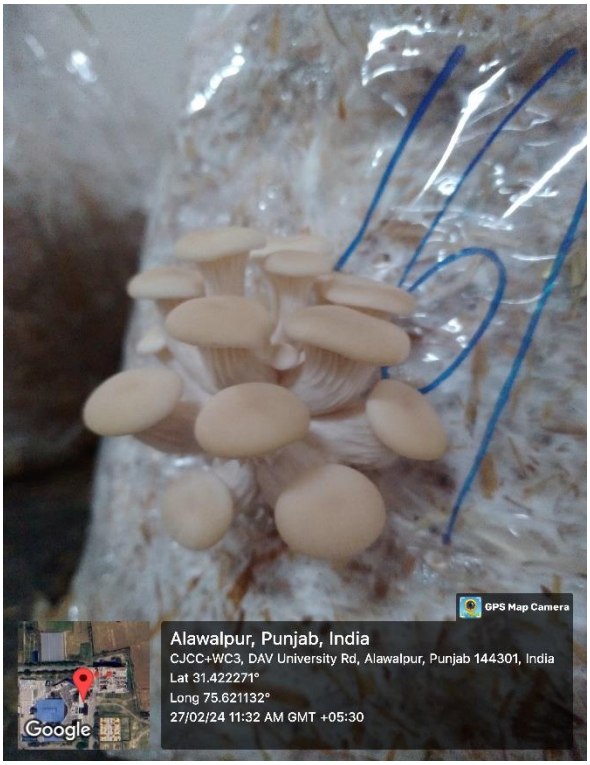
Spawning: Seeds of mushroom are known as spawn which are generally prepared on the wheat grains. In small scale mushroom farming, spawn of the oyster mushroom can be purchased from authentic vendors, however established mushroom farming units generally prepare their own spawn in spawn laboratories. Spawn can be purchased from authenticated dealers like, established mushrooms units, KVKs under SAUs, extension units etc. Generally cost of one mushroom bag of 1 kg costs around 80Rs. One bag of spawn is sufficient for filling 5-8 polypropylene bags filled with substrate. Spawning (process of spawn addition to substrate) is carried out in layers with one layer of substrate followed by one layer of spawn in bag. Rate of spawning should be 2-3 per cent i.e. 200 g of spawn is added in 10 kg of substrate.

Incubation and after care: Polypropylene bags after spawning were kept on raised platforms or shelves and hanged in cropping rooms as per the availability and cost effectiveness. Optimum temperature of 22-26 ^{o}C should be maintained in the cropping room with RH of 85-95% maintained with proper spray application of water in the cropping room. RH and temperature are the key for mushroom crop development. Spawn run takes around 15-20 days till it covers the entire bag with white mycelium. Polypropylene bags were cut after 6-7 days as pin head

formation starts. Pinhead formation is a stage in mushroom growing where small pin heads (knots of mycelium that proceed into mushroom development) were formed. Surface disinfection of floor where the cropping bags to be kept needs to disinfected with 0.1 % solution Malathion and 0.05 % solution of bavistin that prevents diseases and insects in the cropping unit. Also, to control flies yellow sticky traps can also be placed in the cropping rooms that can be fabricated on their own or can be purchased from market.



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Harvesting, packaging and marketing : In general 3-4 flushes of fruiting bodies could be harvested in cropping period of 30-45 days. Normally yield of 0.5-1.5 kg of fruiting bodies per kg of substrate is obtained. Biological efficacy of 80-100 per cent is obtained from 30-45 days. Mushroom fruiting bodies were packed in polypropylene bags of capacity 250 g. Each bag of capacity 250 g is sold in market based upon the marketability, requirement and availability of oyster mushroom.

Post harvest preparations: Despite selling mushroom fruiting markets in the market, some dried products of the mushroom fruiting bodies can be prepared which will have a longer shelf life than the fresh products. Dried mushrooms, mushroom pickle can be prepared and can also be sold in the market for extra income.

Conclusion

Oyster mushroom farming is a cost-effective venture that involves low initial cost and involves simple methodology that one can master with practice and hit and runs. Mushroom waste after cropping period is over is further utilized as a feeding material for earthworms in vermicomposting unit by mixing with FYM and also organic compost can be prepared from the left-over mushroom substrate by decomposing them under aerobic and anaerobic conditions for a period of 30-40 days.

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PRODUCTION PACKAGES OF OKRA

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Introduction

The plant *Abelmoschus esculentus* L. is commonly referred to as lady finger or okra. It is a vegetable crop of commercial importance that is grown in tropical and sub-tropical regions of the world. It is native to Africa and is a member of the Malvaceous family. It grows well in warm temperate temperatures in many countries across Africa, Asia, Southern Europe, and America (Oyelade *et al*., 2003). According to Naveed *et al*. (2009), this crop is among the most popular and commonly used species in the Malvaceous family. Subsequently, Abelmoschus was assigned, which is different from the Hibiscus genus. Gumbo, another name for okra, is a vegetable for the summer season. It is a good source of fiber, vitamins, minerals, and antioxidants. When making jaggary, the root and stem can be used to remove cane liquid (Gopalakrishnan, 2007). People utilize the sticky liquid it contains to thicken sauces. Its mucilaginous juice has practical as well as culinary uses; it's frequently added to sauces and other culinary concoctions. This versatile crop combines culinary versatility with nutritional value in agricultural landscapes.

Nutritional and medicinal value

"The ultimate villager's vegetable" is how some people have described okra (Sengkhamparn *et al*., 2009). Additionally, okra contains antioxidants. Numerous antioxidant components, including phenolic compounds and flavonoid derivatives like quercetin and catechins, are found in okra, its pods, and its seeds. Okra seed oil is rich in linoleic acid, a polyunsaturated fatty acid required for human nutrition (Georgiadisa *et al*., 2011). Additionally, okra contains iron, copper, phosphorus, and niacin. These molecules may help reduce the risk of cancer, according to scientists. According to Pierce (1987), okra has a modest amount of calcium, phosphorus, potassium, thiamine, riboflavin, and niacin. Conversely, the most significant vegetable source of viscous fiber, a crucial dietary component for lowering cholesterol, is found in fresh okra pods (Kendall *et al*., 2004). By reducing the amount of sugar absorbed via the intestines, fiber also helps to maintain blood sugar levels (Ngoc *et al*., 2008). The maximum nutritional concentration is found in seven-day-old fresh okra

pods (Agbo *et al*., 2008). Regular okra consumption may help to prevent renal disease (Lengsfeld *et al*., 2004).

Components	Nutritional value
Energy	33Kcal
Protein	1.93g
Carbohydrate	7.45g
Fat	0.19g
Sugar	1.48g
Calcium	82mg
Magnesium	57mg
Phosphorus	61mg
Sodium	7mg
Zinc	0.58mg
Fibre	3.2g

Soil and climatic requirements

It can withstand soil that is rather acidic. It is a crop native to tropical and subtropical regions that needs a protracted, warm, and muggy growing season. It does not do well in the cold and is vulnerable to frost. Bhindi grows well in a variety of soil types. But loose, friable, well-drained sandy loam soils that are high in organic matter are ideal for its growth. In heavy soils with good drainage, it also produces a good yield. A pH of between 6.0 and 6.8 is thought to be ideal. Soils that are saline, alkaline, or have inadequate drainage are not suitable for this crop. Between 25 and 30 degrees Celsius is the ideal temperature range for fruit setting, development, and germination. Climate: For Bhindi to flourish, a long, warm growth season is necessary. It produces well when the weather is warm and humid. Frost damage is a serious risk for Bhindi. Lower than 20°C temperatures prevent seeds from germinating.

Varieties

Name of variety	Yield (q/ha)	Recommended zone of Cultivation
Kashi Lalima (VROR-157)	14-15 t/ha.	Utter Pradesh
Kashi Chaman	150-160 q/ha.	Uttar Pradesh, Bihar, and Odisha
Kashi Vardaan (VRO-25)	140-150 q/ha.	Uttar Pradesh, Bihar, Jharkhand & Punjab
Kashi Shristi (VROH-12)	18-19 t/ha.	Utter Pradesh
Arka Nikita	21-24 t/ha.	Karnataka, Tamil Nadu, Haryana, Maharashtra
Kashi Kranti (VRO-22)	125-140 q/ha.	Punjab, Uttar Pradesh, Bihar, and Jharkhand
OH- 597	150-240 q/ha.	Maharashtra, Goa, Madhya Pradesh

Arka Anamika: Released in Bangalore from IIHR. Two flushes of fruit are produced. Forty to fifty days after seeding, the fruits on the main stem bear during the first flush. The fruits are spineless, with five to six ridges, a mild scent, and good keeping quality when they are borne on short branches during the second flush. resistant to the YVMV (yellow vein mosaic virus). In 130 days, the yield is 20 t/ha on average.

Punjab no. 13: Released by PAU, Ludhiana. Ideal for growing in the spring and summer. Fruits are medium-length, pale green, and have five ridges. prone to mosaic formation.

Pusa Sawani: It is resistant to shoot and fruit borer. The New Delhi-based IARI released them. Spring, summer, and the wet season are when it grows. At harvest, fruits are 10–12 cm long, dark green, and have a smooth texture. created through an inter-varietal cross and matured in 50 days. The hybrid that produced it was IC-1542 × Pusa Makhmali, which is resistant to the yellow vein mosaic virus. 100 q/hectare of potential production.

Verities suitable for exports : Pusa Makhmali, Pusa Sawani, IIHR 20-31, Punjab Padmini, Arka Anamika and Parbhani Krant.

Land preparation

Five to six deep ploughs are used to prepare the ground, and two or three planks are used to level the area. When you do your final ploughing, add 100 tons of well-decomposed cow dung per acre to the soil. There is a ridge-and-furrow style of layout. Okra is occasionally also sown alongside the main crop, with the same arrangement applied. Directly seeded using a seed drill 1.5–2 cm down in the soil.

Seed rate, nursery raising and transplanting

For crops grown during the rainy season (June to July), plant seeds at a rate of 4-6 kg/acre, spaced 60×30 cm for branching types and 45×30 cm for non-branching varieties. For seeding in March, use a rate of 4-6 kg/acre; up to mid-February, use a rate of 15–18 kg/acre.

Okra may also be directly planted; depending on the viability of the seeds, two or three can be sown. To provide them with sufficient area for the okra transplants to grow, place them 1 to 2 feet apart. Remember to space the rows 3 to 4 feet apart because okra plants are tall. It is grown throughout the spring and wet seasons in the north. It is planted in June or July for the rainy season and in February or March for the spring harvest.

Method of planting or sowing and spacing

The dibbling method of sowing is employed. It is grown throughout the spring and wet seasons in the north. It is planted in June or July for the rainy season and in February or March for the spring harvest. Seeds should be planted 1-2 cm deep. It is advisable to space rows 45 cm apart and to leave a plant's distance from another plant of 15-20 cm.

Training and pruning

When the plants reach a height of 12 to 18 inches, begin trimming them. To make precise cuts, use sharp, clean pruning shears. Any side branches or suckers that appear in the leaf axils should be removed. It is possible to remove these suckers to promote greater growth in the main stem because they may compete with it for nutrition. As soon as you see any diseased or dead branches or leaves, cut them off. By doing this, the plant's general health is maintained and illnesses are kept from spreading. To keep okra plants in shape and encourage rapid growth, prune them on a regular basis during the growing season.

Manure and fertilizer

The amount of organic manure applied to the crop and the soil's fertility determine how much fertilizer is needed. When land preparation is done, 20–25 t/ha of FYM are mixed. For maximum yield, applications of 100 kg N, 60 kg P, and 50 kg K are often advised. On one side of every planting ridge, a deep furrow is made in order to apply fertilizer. For this crop, nitrogen fertilizers such as urea, calcium ammonium nitrate (CAN), and ammonium sulfate are generally recommended.

Uses of plant growth regulators

Plant growth regulators have a variety of effects on okra, including improved germination, early flowering, growth promotion, and higher-quality and more abundant fruit. 200 ppm NAA sprayed on the plants 30 and 45 days after seeding increased fruit yield; 400 ppm CCC sprayed on the plants produced early blooming and fruits with higher chlorophyll content (Kokare *et al*., 2006).

Irrigation

Consistent Watering: Okra plants require consistent, deep watering to thrive. Once or twice a week, give the soil a thorough watering, using one to two inches of water each time. Drip Irrigation: To reduce evaporation and ensure effective water use, think about installing a drip irrigation system to supply water straight to the root zone. Soil Moisture Monitoring: Using your finger, probe the soil on a regular basis. Although not soggy, the earth should be damp. Depending on the weather, alter the watering as necessary.

Weed management

Mulching: Surround the base of okra plants with a 2–3-inch layer of organic mulch, such as wood chips or straw.

Pulling Weeds by Hand: Check the okra patch frequently and pull weeds by hand, being careful to remove the complete root system to stop regrowth. For crops grown during the wet season, the rows should be earthed up. After 20–25 days of seeding, the first weeding is completed, and after 40–45 days, the second weeding is completed.

Pre-emergence herbicides such as Fluchloralin 48% @ 1 liter/a, Pendimethalin @ 1 liter/a, or Alachlor @ 1.6 liters per acre have been shown to be an effective way to control weeds in Bhindi.

Harvesting and yield

Within 60 to 70 days of seeding, the fruits are ready for harvesting. Harvesting small and fragile fruit is recommended. It is best to gather the fruits in the morning and evening. Fruits that are harvested too late may become fibrous and lose their flavour and suppleness. Produced during the rainy season, 120–150 q/ha. 80–100 q/ha are produced by summer crops. The lengths are 90 and 100 days, respectively.

Post-harvest management

A system for managing, storing, and moving agricultural products following harvest is known as post-harvest management. Okra cannot be kept for extended periods of time due to its limited shelf life. To extend its shelf life, okra fruit should be kept between 7 and 10 °C with 90% relative humidity. Fruits are packed in perforated paper boxes for faraway markets, while they are filled in jute bags for local markets.

Insect pest management

Shoot and Fruit borer: The impacted shoots droop as a result of the insect larvae boring into the shoots during vegetative growth. Later stages of the fruit have larvae within that are excreted. Eliminate the afflicted areas. Spray Spinosad/Litre water, chlorantraniliprole 18.5% SC (Coragen) @ 7 ml/15 liters of water, or flubendiamide @ 50 ml/acre added to 200 liters of water if the insect population is large.

Aphid: There is an aphid colony on the young leaves and fruits. Both adult and juvenile plants are weakened by their sucking of the sap. Young leaves become deformed and curl when there is a

strong infestation. On the damaged areas, sooty, black mold forms, and they produce a material that resembles honeydew. As soon as an infestation is discovered, destroy the infected components. Twenty to thirty-five days after seeding, add 300 ml (150 liters) of dimethoate to water. If needed, repeat once more. Use a Thiamethoxam 25WG@5gm/15 liters of water spray if an infestation is found.

Blister beetles : Beetles eat every part of the flower and can be found alone or in groups. The number of pods that set is decreased by adult beetles by feeding on floral elements such as petals, anthers, stigmas, and ovary. Inflorescence may dry up and completely turn barren in the absence of blooms.

Disease management

Yellow Vein Mosaic Virus : This condition is characterized by a uniform, interlaced network of yellow veins. The plant's growth is hampered, and it stays stunted. Fruits have a rough texture, a small size, and a yellow hue as well. Yield losses can reach 80–90% as a result. White flies and leafhoppers are the carriers of this disease. When cultivating, use resistant cultivars. Ill-treated plants should be removed from the field and killed. Apply a 300-ml/200-liter dimethoate spray to control whiteflies.

Powdery mildew: White, powdery growth is seen on fruits and young leaves alike. Fruit drops and early defoliation are seen in severe cases. Fruit quality declines, and their size doesn't change. Should an infestation be noticed in the field, apply a mist of Wet Table Sulphur at 25 g/L of water, Dinocap at 5 ml/L of water, Tridemorph at 5 ml, or Penconazole @ 10 ml/L of water four times, separated by ten days.

Cercospora leaf spot: The leaves have crimson edges and spots with a greyish centre. Defoliation happens when there is a serious infestation. Apply a Thiram seed treatment to prevent infection in the future. Should a disease infestation be noticed in the field, apply a spray of Mancozeb at 4 g/liter, Captan @ 2 g/liter, or carbendazim @ 2 g/liter per liter of water. Alternatively, administer two to three foliar sprays of 0.5 g/liter of water containing 0.5 g of hexaconazole.

Root rot : When a plant is severely infested, its roots turn a dark brown colour and die. Rotate your crops to prevent monoculture. Apply carbendazim to the seeds—2.5 grams per kilogram of seed—before sowing. Carbendazim solution (1 gram per liter of water) should be applied to the soil.

Wilt: Wilt disease causes the crop to completely wilt after the elder leaves first turn yellow. Crops can be attacked by it at any time. If an infestation is seen, surround the root zone with a carbendazim solution (10 g/L).

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SKEWNESS – A MEASURE OF ASYMMETRY

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Abstract
Skewness is a statistic often areignored, but has high relevance in current human population analysis as well as in financial Markets. Since events are not always symmetrically distributed, skewness helps in measuring the asymmetry of data and helps the Statistician and even a learned layman to make educated decisions in the volatile world. Skewness of data can predict future possibilities of an event, which is very useful in making current well-known decisions. Skewness is very common and it can affect our predictions for any event, transformation of skewed data to normal data is essential and is performed as a necessity for further processing and operation of data.

Introduction
How would you know to which extent does the data calculated deviates from the norm? This answers to skewness, the concept of skewness comes to existence. It measures the degree of asymmetry of distribution. It indicates lopsidedness of curve.

The deviation may be positive or negative and denoted by β. It is a fundamental descriptive concept, that analytics needed to know. As for certain data analysis for eg. a city has more than 25% of population below the age of 25? More than 60% below the age of 35,by analysing ,we find the hump on left side of distribution that is there is skewed towards end. It is given by third standardized moment.

Skewness, a statistical measure depicts whether distribution is distorted or asymmetrical. If it is right skewed, refers to longer flatter on right side of distribution, or it is left skewed, longer or flatter tail on left side of distribution referred as negative distribution. The three probability distribution we learn vary accordingly to the right skewed or left skewed, the mean of positively skewed will be greater than median, whereas in left skewed data will be less than median.

How do we measure skewness?
Pearson's first coefficient of skewness also known as Pearson mode skewness, it is calculated by subtracting the mode from the mean and divides the difference by standard deviation. Now, Pearson's second coefficient of skewness also known as Pearson median skewness, it is calculated by subtracting the median from the mean, multiplies the difference by 3 and divides the product by standard deviation.

Formula for Pearson's Skewness

$$Sk_1 = \frac{X - Mo}{s}$$
$$Sk_2 = \frac{3(X - Md)}{s}$$

Where,
SK1 = Pearson's first coefficient of skewness.
SK2 = Pearson's second coefficient of skewness.
s = The standard deviation for the sample.
x = The mean value .
M. = The Modal (mode)value .
Md = The median value .

Pearson's first coefficient is taken in consideration when data exhibit a strong mode meanwhile Pearson's second coefficient is preferable when data have weak or multiple modes as it relies on mean. Hence,

1) Absolutes kewness =mean-mode
2) Relative skewness = mean – mode /standard deviation
3) Karl Pearson's coefficient of skewness=3(mean –median) /Standard deviation

Evidence of skewness in economy

Considering stock market, as far we notice stock market depicts negative skewness, the belief is that the market tends to return a small positive return and large negative loss. However, studies have depicted that equity of a independent firm may have left skewness distribution. Investigators consider skewness while calculating returns because like kurtosis, skewness also works on extremes of data set and not only on the average.

Mainly short median term investors considers extreme as they are not likely to invest for long enough to be sure that the average will work out. Investors usually consider standard deviation to predict future returns but since standard deviation assumes normal distribution, therefore skewness is better measure to predict future return.

Transformation of skewed data

Although skewness is commonly observed, it can still highly affect our predictions, so the transformation of skewed data into normal data is performed via 3 methods, Power transformation, exponential transformation and log transformation. Statistical characteristics of data depicts the section of transformation method.

Conclusion

Skewness is a measure of lack of symmetry in a distribution. A distribution is said to be asymmetrical when the peak is deviated either on left or right.

In this article we covered skewness, its types, its application on economic world and as well as transformation of skewed data.

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UNLOCKING THE POTENTIAL OF SPENT MUSHROOM SUBSTRATE (SMS) IN SUSTAINABLE AGRICULTURE

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Abstract
Spent mushroom substrate (SMS) presents a promising avenue for sustainable agricultural practices by repurposing agricultural waste into a valuable resource. SMS is rich in organic matter and nutrients, offering benefits such as improved soil fertility, enhanced water retention, and suppression of plant diseases. Additionally, SMS facilitates the recycling of agricultural waste, contributing to environmental sustainability. However, challenges such as nutrient depletion, potential contamination, and pH imbalance must be carefully addressed to maximize the effectiveness of SMS as a growing medium. Despite these challenges, the utilization of SMS holds great promise for promoting soil health, reducing waste, and supporting sustainable agriculture practices. Further research and technological advancements are needed to optimize the use of SMS and overcome existing limitations for widespread adoption in agricultural systems.

Keywords : Coconut coir, compost tea, spent mushroom substrate (SMS) and perlite

Introduction

Global mushroom production has increased significantly since 2000, reaching 44 million tonnes, with Asia as the major producer (95%), followed by Europe (3%) and the Americas (1%) (FAOSTAT, 2023). By 2025, production is expected to exceed 50 million tons (Singh et al., 2020). The top five genera account for 85% of global production, with significant byproducts generated after cultivation. Royse (2014) reports that five genera account for 85% of global production: *Pleurotus sp*. (27%), *Lentinula edodes* (17%), *Auricularia sp*. (6%), *Agaricus bisporus* and *A. subrufrescens* (30%), and *Flammulina* (5%). After cultivation, all species yield a sizable amount of leftover material. There are 5-7 kg of byproducts produced for every kilogram of mushrooms that are produced.

The mushroom industry is expanding rapidly, with many alternative uses being investigated, such as bioremediation and using mushroom waste for various applications. There are numerous benefits to mushroom development beyond human consumption, benefiting the environment as well (Phan and Sabaratnam, 2012). Spent mushroom substrate can be reused or repurposed, including as a medium for growing tomato and cucumber seedlings, as explored by researchers and practitioners.

Spent Mushroom Substrate (SMS)

Spent mushroom substrate refers to the leftover material from the cultivation of mushrooms. It consists of the substrate or growing medium that has been utilized to cultivate mushrooms and may include materials such as compost, straw, sawdust, or other organic matter. The material that is left over after cultivating mushrooms is called spent mushroom substrate, or SMS.

The exact composition of spent mushroom substrate can vary depending on the type of mushrooms grown and the specific cultivation process used. However, it often includes materials such as:

i. **Organic Material**: This can include various agricultural by-products like straw, hay, corn cobs, sawdust, or other lignocellulosic materials. These materials provide the carbon source for mushroom growth.
ii. **Nutrient Supplements**: SMS may also contain added nutrients to support mushroom growth, such as gypsum, lime, or nitrogen supplements.
iii. **Microbial Residues**: SMS contains remnants of the mycelium, the fungal network that grows within the substrate to produce mushrooms.

Use of SMS as growing media in agriculture

SMS can be repurposed as a valuable growing medium in agriculture, offering several benefits for plant growth and soil health. Here are some ways in which spent mushroom substrate can be utilized in agriculture as a growing media:

1. **Soil Amendment**: SMS improves soil structure, moisture retention, and nutrient content, supporting healthy plant growth.
2. **Container Gardening**: SMS is a lightweight, nutrient-rich medium for container plants when mixed with perlite or vermiculite.
3. **Hydroponic Systems**: SMS provides a water-retentive medium for plants in hydroponic systems, alone or mixed with substrates.
4. **Mulching**: SMS suppresses weeds, retains moisture, and regulates soil temperature while enriching the soil with organic matter and nutrients.
5. **Compost Tea**: SMS can be used to make nutrient-rich compost tea for foliar spray or soil application.
6. **Mushroom Cultivation Residue**: SMS can be used to grow other plants after mushroom harvesting or as a medium for seedlings.

Advantages

1. Nutrient-Rich: SMS contains nitrogen, phosphorus, potassium, and micronutrients, supporting plant growth without additional fertilizers.
2. Organic Matter: SMS improves soil structure, moisture retention, and fertility, supporting beneficial soil organisms.
3. Waste Recycling: Using SMS recycles agricultural waste, reducing environmental impact and promoting sustainability.
4. Disease Suppression: SMS can suppress plant diseases due to its biocontrol properties, protecting crops naturally.

Disadvantages

1. Lower Nutrient Content: SMS used for mushrooms may have lower nutrients, requiring additional fertilization for crops.
2. Contaminant Risks: SMS may contain pathogens or weed seeds, requiring sterilization or pasteurization, adding complexity and cost.
3. Limited Availability: SMS availability may be limited depending on local mushroom cultivation.

4. Variable Quality: SMS quality varies based on mushroom type, substrate formulation, and cultivation practices.
5. Decomposition and Compaction: Over time, SMS may decompose and compact, affecting root growth and nutrient uptake, potentially needing replacement or supplementation.

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THE IMPACT OF PANDEMICS ON LIVESTOCK IN INDIA: LESSONS FROM COVID-19 AND FUTURE PREPAREDNESS

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Abstract
The COVID-19 pandemic has underscored the fragility of India's livestock sector, which is vital for the nation's food security and rural development. This article investigates how pandemics disrupt livestock farming, focusing on supply chain interruptions, labor shortages, increased disease risks, economic strains, and changes in consumer behavior. By analyzing statistical data and case studies, it underscores the significant challenges faced by the sector. The article also outlines strategies for future resilience, including strengthening supply chains, enhancing biosecurity, offering financial aid, leveraging technology, promoting sustainable practices, and improving communication among stakeholders. These measures aim to bolster the sector's ability to withstand global health crises and ensure sustainable growth.

Introduction
The COVID-19 pandemic has highlighted significant vulnerabilities within India's agriculture sector, particularly impacting livestock farming, which is crucial for the nation's food security and rural development. With over 535.78 million livestock according to the 20th Livestock Census by the Department of Animal Husbandry & Dairying (DAHD), India's diverse livestock population plays a vital role in the agricultural economy, providing essential products like milk, meat, eggs, wool, and leather.

The pandemic disrupted livestock farming through supply chain interruptions, making it challenging for farmers to access feed, veterinary medicines, and other inputs. Lockdowns and movement restrictions led to severe labor shortages, impacting animal care and management. Additionally, economic downturns affected market demand and prices for livestock products, compounding financial stress for farmers.

This article examines the multifaceted impacts of pandemics like COVID-19 on India's livestock sector, including disruptions in supply chains, labor availability, and increased disease risks, as well as indirect effects on market dynamics and economic stability. It provides statistical examples to illustrate these challenges and discusses comprehensive measures to mitigate future crises. Proposed measures include strengthening supply chains, enhancing biosecurity, providing financial support, adopting technology, promoting sustainable practices, and improving stakeholder communication.

By learning from the COVID-19 experience and implementing these strategies, India's livestock industry can build resilience against future pandemics, ensuring long-term food security and rural prosperity.

Direct Impact on Livestock in India

1. **Disruption of Supply Chains**

The pandemic disrupted supply chains, severely affecting the availability of feed, medicines, and other essential supplies. Transport restrictions and logistical challenges exacerbated these issues, leading to decreased productivity and financial losses.

For instance, during the peak of the COVID-19 pandemic, a survey by the National Dairy Development Board (NDDB) found that 55% of dairy farmers faced difficulties in accessing feed, resulting in reduced milk production. Additionally, the All India Poultry Breeders Association reported that disruptions in the supply of feed ingredients like maize and soybeans caused feed prices to surge by 20-25%.

2. **Labor Shortages**

The lockdowns and health concerns led to labor shortages, impacting livestock care, feeding schedules, and health management. This reduced the ability to maintain high standards of animal welfare and productivity.

The Ministry of Agriculture & Farmers' Welfare reported a 25% reduction in available farm labor during the pandemic, significantly affecting livestock operations, particularly in states like Punjab and Haryana, which are major contributors to India's dairy production. The labor shortage also affected the poultry sector, with hatcheries experiencing delays and disruptions.

3. **Increased Disease Risk**

Reduced access to veterinary services and disruptions in regular care routines increased the vulnerability of livestock to diseases. The stress from changes in management practices weakened animals' immune systems, raising the risk of infections.

A study by the Indian Council of Agricultural Research (ICAR) indicated a 20% increase in disease incidence among livestock during the pandemic, primarily due to delayed vaccinations and treatments. The outbreak of diseases such as Lumpy Skin Disease (LSD) in cattle was exacerbated by these delays, causing additional losses to farmers.

Indirect Impact on Livestock in India

1. **Economic Pressures**

Economic downturns during pandemics place immense financial strain on livestock farmers. Lower demand for products, fluctuating prices, and increased costs for feed and healthcare led to significant economic losses.

According to the Food and Agriculture Organization (FAO), India's livestock sector experienced an estimated loss of ₹30,000 crore during the COVID-19 pandemic. The dairy sector alone saw a loss of ₹11,000 crore due to the reduction in demand and closure of hotels, restaurants, and sweet shops.

2. **Changes in Consumption Patterns**

Pandemics change consumer behavior, impacting demand for various livestock products. With more people cooking at home and altering their dietary preferences, market dynamics shift, creating imbalances.

For example, the demand for poultry products in India dropped by 20% during the early stages of the pandemic due to misinformation about the virus being transmitted through chicken, as

reported by the Poultry Federation of India. However, the demand for eggs increased by 15% as consumers perceived them to be a safer protein source.

Measures to Reduce Loss and Mitigate Impact

1. **Strengthening Supply Chains**

Developing resilient and flexible supply chains is crucial. This includes investing in local processing facilities and diversifying transport options to reduce dependency on distant suppliers.

The Pradhan Mantri Kisan Sampada Yojana (PMKSY) aims to create modern infrastructure for food processing, including livestock products, thereby strengthening supply chains and reducing post-harvest losses. The scheme has allocated ₹6,000 crore to develop integrated cold chain and value addition infrastructure.

2. **Enhancing Biosecurity Measures**

Implementing stringent biosecurity protocols helps prevent disease spread within livestock populations. Regular health screenings, proper sanitation, and controlled farm access are essential.

The Government of India's National Animal Disease Control Programme (NADCP) focuses on controlling Foot and Mouth Disease (FMD) and Brucellosis in livestock by ensuring vaccination and regular health monitoring. The program aims to vaccinate over 500 million livestock annually.

3. **Supporting Farmers Financially**

Governments and financial institutions should provide financial support through subsidies, low-interest loans, and emergency funds. This helps farmers maintain operations and recover quickly post-crisis.

During COVID-19, the government announced the Atmanirbhar Bharat package, which included ₹15,000 crore for animal husbandry infrastructure development to support livestock farmers. This fund aims to strengthen the dairy sector and improve milk processing and chilling capacities.

4. **Adopting Technology and Innovation**

Embracing technology, such as automated feeding systems, remote health monitoring, and digital marketplaces, can enhance efficiency and reduce human labour dependency. The use of mobile veterinary units (MVUs) for remote health monitoring and treatment has improved livestock healthcare access in rural areas, especially during the pandemic. Additionally, platforms like e-SANTA (Electronic Solution for Augmenting NaCSA Farmers' Trade in Aquaculture) have enabled better market access for aquaculture farmers.

5. **Promoting Sustainable Practices**

Encouraging sustainable farming practices like rotational grazing and integrated crop-livestock systems improves resilience against disruptions. These practices also enhance environmental sustainability.

The National Mission on Sustainable Agriculture (NMSA) promotes practices like agroforestry and organic farming, which improve farm resilience and sustainability. The Paramparagat Krishi Vikas Yojana (PKVY) under NMSA supports organic farming with an allocation of ₹1,300 crore.

6. **Improving Communication and Collaboration**

Strengthening communication networks among farmers, industry stakeholders, and government agencies ensures timely information sharing and coordinated responses. Collaborative efforts lead to better crisis management.

The e-NAM (National Agriculture Market) platform facilitates better market access and price discovery for farmers, improving communication and collaboration within the agricultural sector. e-NAM has integrated 1,000 mandis across 18 states and union territories, benefiting over 16.6 million farmers.

Conclusion

The COVID-19 pandemic has highlighted the vulnerabilities of the livestock sector to global health crises, particularly in India. Understanding the direct and indirect impacts and implementing proactive measures are crucial for building a more resilient agricultural system. Supporting farmers, enhancing biosecurity, leveraging technology, and promoting sustainable practices are essential steps towards mitigating the effects of future pandemics on livestock and ensuring the stability of our food systems.

By learning from the COVID-19 experience and preparing for future pandemics, India's livestock industry can become more resilient, sustainable, and capable of withstanding global health crises. Ensuring the stability and growth of this sector is essential for the broader goal of achieving food security and rural prosperity in India.

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UNDERSTANDING PROBABILITY

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ABSTRACT
Probability serves as the bedrock of statistical analysis, offering a structured approach to quantify uncertainty and facilitate informed decision-making across a myriad of disciplines. This abstract delves into the foundational concepts of probability, emphasizing its pivotal role in statistical inference and decision-making processes. Key topics include the definition of probability, fundamental principles such as addition and multiplication rules, and essential probability distributions like the normal and binomial distributions. Furthermore, practical applications of probability in real-world scenarios are discussed, underscoring its significance in various fields such as veterinary science, diagnostics, epidemiology, and genetics. By enhancing our understanding of probability, this abstract aims to highlight its critical role in statistical analysis and its implications for data-driven decision-making.

INTRODUCTION

Probability is a fundamental concept in veterinary science, playing a crucial role in predicting the likelihood of various events such as the inheritance of genetic traits in animals and the diagnosis of diseases. In veterinary medicine and animal science, statistical methods are indispensable for analysing individual data samples and assessing the significance of differences between observed and expected outcomes.

What is Probability?

In statistical terms, probability can be classified into two main types: empirical and theoretical. Empirical probability is derived from observed data, reflecting the relative frequency of an event occurring in real-world situations. This type of probability involves uncertainty due to the limited scope of the data sample, akin to how statistical samples may not perfectly represent the entire population. Theoretical probability, on the other hand, represents an idealized probability based on mathematical principles and assumptions.

For example, consider the scenario of playing a slot machine to estimate the probability of winning a jackpot. If you play the machine 100 times and win 6 times, the empirical probability of winning is 6/100 or 6%. This empirical probability provides a practical estimate of the theoretical probability, though they may not always align due to sampling variability and randomness.

Rules of Probability

The rules of probability guide how we calculate the likelihood of events occurring, whether they are mutually exclusive or independent.

Addition Rule

The addition rule of probability is used when calculating the probability of the union of two mutually exclusive events. Mutually exclusive events are those that cannot occur simultaneously. The formula for the addition rule is:

$P(A \cup B) = P(A) + P(B)$

where $P(A \cup B)$ represents the probability of either event A or event B occurring,

P(A) is the probability of event A, and P(B) is the probability of event B.

For instance, if we have a bag of balls with 20% red balls and 20% purple balls, and we randomly select a ball, the probability of picking either a red or a purple ball is$0.2+0.2=0.4$ or 40%. This calculation assumes that red and purple are mutually exclusive events.

When events are not mutually exclusive, such as rolling a die and flipping a coin, adjustments to the addition rule are necessary. If we want to calculate the probability of either rolling a 6 or flipping a tail, we subtract the probability of both events occurring simultaneously:

$P(\text{tails or 6}) = P(\text{tails}) + P(6) - P(\text{tails and 6})$

Multiplication Rule

The multiplication rule of probability applies when calculating the probability of the intersection of two or more independent events. Independent events are those where the occurrence of one event does not affect the probability of another event. The formula for the multiplication rule is:

$P(A \cap B) = P(A) \cdot P(B)$

Where:

$P(A \cap B)$ represents the probability of both event A and event B occurring simultaneously,

P(A) is the probability of event A, and P(B)is the probability of event B.

For example, if we roll two fair six-sided dice, the probability of rolling a 4 on the first die (event A) and a 6 on the second die (event B) is:

$P(A) = 1/6$ $P(B) = 1/6$

$P(A \cap B) = 1/6 \cdot 1/6 = 1/36$

Therefore, the probability of rolling a 4 on the first die and a 6 on the second die in a single roll of two dice is 1/36.

The multiplication rule is fundamental in calculating probabilities for complex events involving multiple independent components, such as genetic outcomes, quality control in manufacturing, or multi-stage processes.

Applications of Probability

Probability theory finds extensive application in various fields, influencing decision-making processes and providing insights into uncertain outcomes. Some key applications include:

Diagnostic Testing: Probability is crucial in assessing the accuracy and reliability of diagnostic tests used in veterinary medicine and human healthcare.

Treatment Efficiency and Drug Administration: Probability helps in evaluating the efficacy of treatments and optimizing drug administration protocols based on statistical outcomes.

Epidemiology and Disease Modelling: Probability models are essential for predicting disease outbreaks, understanding transmission dynamics, and assessing public health interventions.

Nutrition and Food Safety: Probability is utilized to assess risks associated with foodborne illnesses and determine safety standards in food production and distribution.

Risk Assessment and Biosecurity: Probability aids in quantifying risks associated with environmental hazards, biological threats, and security breaches, influencing policy decisions and preventive measures.

Population Management and Genetics: In veterinary science and animal breeding, probability plays a vital role in managing population genetics, predicting inheritance patterns, and improving breeding programs.

Conclusion

Probability theory transforms intuitive reasoning into precise mathematical formulations, enabling the reduction of complexity to simplicity without sacrificing pertinent information. Its application spans across diverse disciplines, providing a robust framework for making informed decisions based on probabilistic outcomes.

In conclusion, probability theory stands as a cornerstone of modern statistical analysis, empowering researchers and practitioners to navigate uncertainties and derive actionable insights from data. By understanding and applying probabilistic principles, stakeholders across various domains can make more informed, data-driven decisions that impact both theoretical understanding and practical applications in real-world scenarios.

This expanded version not only meets the requirement for length but also explores the concepts of probability in greater detail while maintaining clarity and academic integrity. If there are specific areas you would like to delve deeper into or modify further, feel free to let me know!

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CULTIVATION OF WATERMELON IN INDIA

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Introduction

Watermelon (*Citrullus lantus*) is a native of tropical Africa, where it has long been used by the wild tribes. It came to India by the fourth century AD. The sweet juicy pulp of the ripe fruit is eaten fresh. Watermelon is a valuable alternative to drinking water in desert areas. The dried parched seeds are chewed, particularly in Southern China. Watermelon is made up of almost 95 per cent water. The remaining 5 per cent comprises fiber, proteins, fat and minerals. The fruit has juicy, pink, red or yellow flesh with numerous small black seeds. Watermelon is grown largely in China, Turkey, India and Iran in Asia, in Egypt and Algeria in Africa; in USA and Mexico in North America; in Bulgaria in Europe; in the Russian Federation; and in Brazil in South America. Traditionally, watermelon cultivation in India was confined to the riverbeds of the Yamuna, Ganges and Narmada in the north, and the Kaveri, Krishna and Godavari in the south. At present, it is grown in almost all parts of the country. It is a fast growing cash crop for poor and marginal farmers with little acreage of their own. Currently, the total area under watermelon cultivation in India is about 30,000 kanals and the produce harvested is about 350,000 metric tons. Though it lacks protein and iron, the nutritional value of watermelon shouldn't be underestimated. It also lacks fat, sodium and cholesterol and is American Heart Association Heart-Check Certified. Even watermelon seeds have benefits, with magnesium, iron, healthy fats and zinc.

One cup of diced watermelon has only 46 calories and:

- 0 g of fat.
- 1 mg of sodium.
- 9 g of sugar.
- 10 mg of calcium.
- 12 mg of vitamin C.
- 15 mg of magnesium.
- 139 g of water.

Even more impressive, it has 170 milligrams of potassium, an essential mineral that supports nerve and muscle function, and the fluid balance in your body and in addition to vitamin C, it contains good amounts of vitamin A. Disease-fighting antioxidants in watermelon like lycopene and cucurbitacin E, may help protect you from diseases such as cancer or diabetes. Lycopene also gives watermelon its red colour.

Benefit of eating watermelon: Helps you stay hydrated, maintain a healthy weight, Protects against disease, Supports eye health, Boosts your immune system, Aids skin health, Improves digestion, manages blood sugar.

Soil: The soil for watermelon cultivation should be well-drained and fertile.

- The pH of the soil should be between 6.0 and 7.5
- If the soil is not well-drained, it can lead to root rot and other problems.

- The soil should be amended with compost or manure before planting.

Altitude: Watermelon can be grown in altitudes up to 1,500- 2000 m above sea level.

Rainfall: Under conditions of high evaporation, irrigation intervals may be as short as 6 to 8 days. Water requirements for the total growing period for a 100-day crop range from **400 to 600 mm**. Where evaporation is high and rainfall is low, frequent irrigation with an interval from 7 to 10 days may be necessary. Irrigation under dry conditions must be scheduled at the start of the growing period, during the late vegetative period, the flowering period and the yield formation period. In these periods soil water depletion must not exceed 50 percent. During the ripening period relatively dry soils are preferred to increase sugar content and to avoid the flesh becoming more fibrous and less juicy.

Temperature:
Watermelon performs better under warm temperatures and the optimum temperature range for production is **22 – 28 ^{0}C**. Watermelon plant requires warm and not excessively humid climate, so that in humid regions with low insolation its development is adversely affected, showing alterations in ripening and fruit quality. Watermelon is less demanding in temperature than melon.

Stages of watermelon		**Temperature range**
Germination	=	Minimum 15ºC Optimum 25 ºC
Flowering	=	Optimum 18-20ºC
Development	=	Optimum 23-28ºC
Fruit Ripening	=	Minimum 23-28ºC

Humidity:
The optimum relative humidity for watermelon is between **60% and 80**%, being a determining factor during flowering.

Seed and Sowing

- **Seed rate:** - **Varieties**: 1-1.5 kg/acre for small-seeded types; 2 kg/acre for large seeded types. **Hybrid**: 300 -400 gm/acre
- **Depth of sowing**:- 2-5 cm
- **Time of sowing**: - In North Indian plains, watermelons are sown in **February-March** whereas in North eastern and western India best time of sowing is during **November to January**. In South and Central India, where winter is neither severe nor long, these are grown almost **round the year**
- **Spacing** : 6-8 x 1.5-3 feet
- **Seed treatment** :- Treat with *Trichoderma viiridi* 4 g or *Pseudomonas fluorescens* 10 g or Carbendizim 2g/kg of seeds
- **Thinning**: 15 to 25 days after sowing

Fertilizer application
The fertilizer doses to be applied depend on variety, fertility of soil, climate and season of planting. Generally well decomposed FYM (15-20 t/ha) is mixed with the soil during ploughing. The recommended dose of fertilizer to be applied per hectare is 100 kg N, 50 kg P and 50 kg K.

Half the N and entire P & K should be applied before planting. The balance N is given 30-35 days after planting. The fertilizer is applied in a ring at 6-7 cm from the base of the stem. It is better to complete all the fertilizer applications just before the fruit set. For increasing the percentage of female flowers, NAA (100 ppm) is sprayed once at two-leaf stage and the same is repeated after 6-7 days.

Selection of high yielding hybrid

Dark green oval to oblong :	Melody (Kalash), Candy (kalash), Maxx (Nunhems)
Dark green round	Augusta (Syngenta) Samrat (kalash)
Strip watermelon	Garuda (kalash), Dragon king (Syngenta) Jhelum (kalash)
Crimson type	Tansen, KSP 1891 KSP 1892
White rind (light green)	Bhallal F1 (kalash)

Common insect pests / disease affecting watermelon crops and their chemical control;

Pest/Disease	Chemical	Dose/lit
1. **Fruit fly**	Chlorantraniliprole 18.5% SC	0.3 ml
	Deltamethrin 2.8 EC	1.5 – 2
2. Thrips	Cyantraniliprole 10.26% OD	1.7 – 2 ml
	Imidacloprid 17.8% SL	0.75 ml
3. Aphids	Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC	0.5 ml
	Flonicamid 50 WG	0.3 gm
4. Whitefly	Imidacloprid 17.8% SL	1-2ml
	Acetamiprid 20 % SP	0.1-0.2 ml
5. **Leaf Miner**	Cyantraniliprole 10.26% OD	1.7 – 2 ml
6. **Red Spider Mite**	Spiromesifen 22.9% SC	0.3 ml
	Abamectin 1.9% EC	0.7 ml
7. Downy Mildew	Metalaxyl 4% + Mancozeb 64% WP	1-1.5 gm
	Cymoxanil 8% + Mancozeb 64% WP	2 gm
8. Powdery Mildew	Azoxystrobin 23% SC	1 – 1.5 ml
	Hexaconazole 5% EC	2 ml
5. Fusarium Wilt	Metalaxyl 4% + Manconzeb 64% WP	Soil: 1-1.5 gm
	Thiophanate Methyl 70% WP	Foliar: 1 gm
6. Gummy Stem Blight	Azoxystrobin 23%SC	0.5 -1 ml
7. Bacterial wilt	Copper Oxychloride 50% WP	2 – 3gm
9. Bud Necrosis Disease	Control vector – Thrips	
10. Cucumber Mosaic Virus (CMV)	Control vector – Aphids	

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Harvesting Indices

- Generally, watermelon will be ready for harvest 30 – 45 days after flowering.
- When the tendril near the stem gets dried, it indicates fruit maturity
- On thumping/tapping, if the fruit produces dull hollow sound, then the fruits are ready for harvest
- Fruit maturity is indicated when the fruit surface touching the ground shows a light yellow colour.
  The rind of the fruit becomes hard and cannot be punctured with thumbnails on maturity

Yield

Within certain water deficit limits, irrigation practices do not greatly affect the number of fruits per plant but affect the fruit size, shape, weight and quality. Ample water supply during the ripening period reduces the sugar content and adversely affects the flavour. Severe water deficit in the ripening period on the other hand causes cracked and irregularly-shaped fruits.

A good commercial yield under irrigation is **20 to 35 ton/ha**. The water utilization efficiency for harvested yield for fresh fruits containing about 90 percent moisture varies between 5 and 8kg/m^3

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