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From the Editor-in-Chief's Desk

I am happy and proud to announce the release of the Eighth issue of AgriTech Today Magazine.

In this edition, we delve into the promising landscape of agricultural technology. Through insightful narratives, expert opinions, and success stories from the field, we aim to shed light on the transformative potential of technology in addressing global food challenges while advocating for an inclusive, technology-driven agricultural revolution.

It gives me great pleasure to inform you that we have curated and finalized 57 articles for publication in this issue. My sincerest hope is that this issue will provide readers with valuable insights into agricultural technologies and innovations.

My sincerest hope is that this issue will provide readers with valuable insights into agricultural technologies and innovations. I extend my heartfelt gratitude to the dedicated editorial team and the talented authors for their invaluable contributions in bringing this issue to fruition. Your efforts have played a pivotal role in making AgriTech Today Magazine a source of enlightenment and knowledge in the agricultural domain.

Editor-in-chief

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Dryland farming is frequently defined as crop production in areas with less than 500 mm of annual precipitation, but this definition omits a critical component of the equation, evaporation potential. Operatively, dryland farming is practiced where annual potential water evaporation exceeds annual precipitation. Dryland farming is agriculture dependent upon the vagaries of weather, especially precipitation. In its broadest aspects, dryland farming is concerned with all phases of land use under semiarid conditions. Not only how to farm but how much to farm and whether to farm must be taken into consideration. Above all else, dryland farming must emphasize the capture and efficient use of precipitation.

Dry farming depends on making the best use of the "bank" of soil moisture that was created by winter rainfall. Some dry farming practices include:

- Wider than normal spacing, to provide a larger bank of moisture for each plant.
- Controlled Traffic.
- Minimal tilling of land.
- Strict weed control, to ensure that weeds do not consume soil moisture needed by the cultivated plants.
- Cultivation of soil to produce"dust mulch", thought to prevent the loss of water through capillary action. This practice is controversial and is not universally advocated.
- Selection of crops and cultivars suited for dry farming practices.

Principles of Successful Dryland Farming

Dryland farming in India depends on 3 principles:

1. Precipitation of the land must be retained.
2. Opting of methods that can retain soil moisture to avoid evaporation or transpiration.
3. Using drought-resistant crops that aren't reliant on heavy and frequent rainfall.

Importance of Dry land Farming for India

Considering the present rate of development of irrigation facilities and also water potentiality of the country, it is estimated that at any point of time 50% of cropped area in India will remain under Rainfed farming system. Such vast areas as of now consume hardly 25% of total fertilizer consumption of the country. Due to poor level of management, crop productivity is also very low resulting in socio – economic backwardness of the people.

Food Security: Dryland farming contributes to India food security by providing a substantial portion of the country staple crops such as millets pulses, oilseeds and coarse grains.

Crop Diversity: Dryland farming encourages the cultivation of a variety of droughts resistant crops. This diversity reduces the vulnerability of agriculture to the impacts of climate change and erratic rainfall patterns.

Livelihood: A significant proportion of India population particularly in rural area is dependents on dryland farming for their livelihood. This form of agriculture support millions of farmers and labours contributing to poverty alleviation and rural development.

Biodiversity Conservation: Dryland practices such as agroforestry and mixed cropping can help conserve biodiversity by promoting the growth of a range of plants and tree species and creating habitats for wildlife.

Water resource Managements: Dryland farming encourages the efficient use of water resources. Farmers in these regions often rely on rainfed agriculture and as results employ techniques like: rainwater harvesting and efficient irrigation systems to manage water scarcity.

Characteristics of Dryland Agriculture

Dry land areas may be characterized by the following features:

- Uncertain, ill-. distributed and limited annual rainfall.
- Occurrence of extensive climatic hazards like drought, flood etc.
- Undulating soil surface.
- Occurrence of extensive and large holdings.
- Practice of extensive agriculture i.e., prevalence of mono cropping etc.
- Relatively large size of fields.
- Similarity in types of crops raised by almost all the farmers of a particular region
- Very low crop yield.
- Poor market facility for the produce.
- Poor economy of the farmers; and
- Poor health of cattle as well as farmers.

Key elements of effective combat with perils of Dryland agriculture

- Capturing and Conservation of Moisture
- Effective Use of Available Moisture
- Soil Conservation
- Control of Input Costs

Problems of Dry Farming in India

Dry Farming in India faces several problems:

1. **Erratic Rainfall Patterns:** Many drylands area in India experience erratic and unpredictable rainfall pattern with long dry spells followed by intense rainfall events. This inconsistency can lead to crop failure and reduce yields.
2. **Water scarcity:** Access to water resources is significant challenge in dryland farming area. Farmers often rely on rainfed agriculture which is highly dependent on the monsoon season. Insufficient rainfall and inadequate irrigation facilities can lead to water scarcity for crops.
3. **Soil Erosion and Degradation:** Dryland soils are susceptible to erosion and degradation due to factors like: wind, water, over cultivation. Soil erosion can reduce soils fertility disrupt root structure and lead to reduce crop yield.
4. **Low Productivity:** Dryland crop typically have productivity compare to irrigated crops. The lack of moisture and water resource restricts crop growth and limits yield potential. 5.
5. **Low Pest and Disease Pressure:** Dryland area often challenges related to pests and disease as arid condition can stress crops and make them more susceptible to infestations. Integrated Pest Management strategies are essential but can be resource intensive.6.
6. **Lack of Quality Seeds**: Access to high quality and droughts resistant crop varieties is essential for dryland farming. Many regions face challenges in obtaining such seeds limiting the potential for improved crop yields. 6.
7. **Economic vulnerability:** Dryland farmers may be more economically vulnerable on rainfall making them susceptible to income fluctuations caused by droughts or excessive rainfall.
8. **Limited Government Supports:** In some dryland regions govt. support in the form of agricultural extension services technology dissemination and financial assistance is limited which can hinder the adoption of improved farming practices.

Principal Dry Farming Zones in India

The principal dry farming zones in India include:

1. **Northwestern Region (Rajasthan and parts of Gujarat):** The northwestern region of India, including the Thar Desert in Rajasthan and parts of Gujarat, is one of the most arid areas in the country. Rainfall is very low, and farming is challenging due to water scarcity and high temperatures. Farmers in this region often practice drought-resistant crop cultivation, such as pearl millet and sorghum.
2. **Western Plateau and Hills (Maharashtra, Karnataka, and parts of Madhya Pradesh):** The western plateau and hilly regions of India, particularly parts of Maharashtra, Karnataka, and Madhya Pradesh, are characterized by semi-arid conditions. Here, dryland farming practices are common, and crops like millets, oilseeds, and pulses are cultivated. These areas often experience rainfed agriculture with a high reliance on the monsoon.

3. **Deccan Plateau (Andhra Pradesh, Telangana, and parts of Karnataka):** The Deccan Plateau is another dry farming region where, farmers face challenges due to low and erratic rainfall. Crops like red gram (pigeon pea), groundnut, and sorghum are grown in this region. Watershed development and rainwater harvesting practices are often implemented to address water scarcity.
4. **Gangetic Plains (Parts of Uttar Pradesh and Bihar):** Some parts of the Gangetic plains, particularly in eastern Uttar Pradesh and Bihar, are prone to dryland farming conditions. These regions experience less rainfall than other parts of the Gangetic plains and require drought-resistant crops like maize, pearl millet, and pulses.
5. **Western Rajasthan:** In addition to the Thar Desert, western Rajasthan, including areas like Bikaner and Jaisalmer, is known for extreme aridity. Farmers here face severe water scarcity, and dryland farming techniques are employed to grow crops like bajra (pearl millet) and guar.
6. **Rayalaseema Region (Andhra Pradesh):** The Rayalaseema region in Andhra Pradesh is semi-arid and experiences water scarcity. Farmers in this region practice dryland farming and grow crops like groundnut, sorghum, and sunflower.
7. **Bundelkhand Region (Uttar Pradesh and Madhya Pradesh):** The Bundelkhand region straddles Uttar Pradesh and Madhya Pradesh and is known for its dry and drought-prone conditions. Farmers here cultivate drought-resistant crops, such as chickpeas, pearl millet, and pigeon pea.
8. **Marathwada Region (Maharashtra):** Marathwada, located in the southeastern part of Maharashtra, faces recurrent droughts and water scarcity. Dryland farming is a common practice in this region, with crops like sorghum, pearl millet, and chickpeas.

Conclusion: These dry farming zones have specific agro-climatic conditions and challenges. Sustainable agricultural practices, water resource management, and crop diversification are crucial for the success of farming in these areas. Additionally, government support and initiatives for dryland farming are essential to improve the livelihoods of farmers in these regions.

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Resistant Gene Analog (RGA) in Plant Disease Management

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Abstract

Plants are susceptible to numerous biotic and abiotic stresses during their life cycle. Abiotic stress includes high or low temperature, drought, floods and biotic stresses include diseases caused by fungi, bacteria, viruses, nematodes, mites and insects. Plant immune system has evolved into a specific mode by years of co-evolution and host-microbe interactions resulting in enormous complexity at both the cellular and molecular levels. Plants have developed effective mechanisms mediated by R-genes which activate strong immune defence. Resistance genes (R-genes) are very valuable resources to better understand plant defence mechanism and develop disease resistant varieties or hybrids. Resistant Gene Analogues in plants are large class of potential R-genes which have conserved domains and motifs related to the NBS-LRR, receptor like kinases, receptor like proteins with their structural features. These conserved motifs are facilitating the use of RGA from distantly related plants. Those conserved natures of sequences help scientists to fish out resistance gene over species and genera. These sequences are used as probes to identify similar sequences in other plant, variety or species.

Introduction

Plant immune system is less complex than its animal counterpart and there are some fundamental differences between plants and animals. Somatic circulatory adaptive immune system and mobile immune cells are absent in plants. Plants are entirely dependent on their innate immune responses in each and every individual cell. Plant immune system has evolved into a specific mode by years of co-evolution and host-microbe interactions resulting in enormous complexity at both the cellular and molecular levels. The cells recognize systemic signals from the infection site and finally develop resistance responses to that particular pathogen. Genes in the plant genome that convey resistance against pathogen by producing R proteins are Resistance genes. These genes are very valuable resources to better understand plant defense mechanism and develop disease resistant varieties/hybrids. The main function of R-genes is initiation of plant defense-signaling mechanism and detection of plant-specific pathogen elicitors (Morel and Dangl, 1997). Kabi *et al.* (2017) studied the molecular analysis of twenty-six different green gram genotypes to link the available RGA markers with YMV resistance by using a resistant gene analog (RGA) marker named CYR1 which produced amplicon at 90 bp in seven genotypes. They concluded that seven genotypes had yellow mosaic virus resistance gene and the marker was an efficient and ubiquitous for genotyping of YMV reaction. OBGG 2013-20 was an YMV resistance and high yielding line which can be used as YMV donor or can be released as a variety. CYR1-RGA marker was completely linked with YMV resistance and would assist in identifying plants endowed with resistance locus conferring aid in the development of resistant cultivars in relatively shorter time span (Reddy and Naresh, 2018).

A study was carried on the cloning of RGAs from a genomically under-utilized crop, finger millet (*Eleusine coracana*) to identify functional disease resistance genes. Comparison of finger millet RGA to sequences available in NCBI database revealed that it was most similar to NBS-LRR proteins from other plant species especially the cereal, rice. The greatest similarity was shown with RPS2 like disease of kinase 2 motif which is indicative of the non-TIR sub-class of R-genes, the prominent class of R-genes. Phylogenetic analysis of finger millet RGA with various classes of plant RGAs indicated that they formed a cluster with RPS2 type NBS-LRR proteins and among them it was closer to rice. RPS2 type R-genes that were reported in other plant species were used for phylogenetic analysis and finger millet RGA formed a cluster together with *Oryza sativa* RPS2 protein indicating the phylogenetic closeness of rice (Jacob, 2017).

Resistance gene classification

Class	Function	Examples of R gene
1	Membrane associated, transcription regulating broad spectrum resistance	*RPW8*
2	Cytoplasmic signal transducing serine-threonine protein kinase	*PTO*
3	Extracellular LRRs with transmembrane anchor	*Cf-2 – Cf-9*
4	Extracellular LRRs, with a transmembrane receptor and a cytoplasmic serine-threonine kinase	*Xa21*
5	Cytoplasmic, membrane associated, Contain LRRs, NBS, and TIR domain	*RPP5, N*[1]*, L6*
6	Also cytoplasmic, membrane associated, contain LRRs, NBS, and a coiled coil domain	*RPM1, RPS2*

Zhou *et al.* (2019) validated 10 target RGAs in chickpea for their differential expression in response to *A. rabiei* infection. Assessed gene expression at each RGA locus via qPCR at 2, 6, and 24 h after *A. rabiei* inoculation with a previously characterized highly aggressive isolate. Among four varieties including two resistant cultivars (ICC3996 and PBA Seamer), one moderately resistant cultivar (PBA HatTrick) and one susceptible cultivar (Kyabra), RGAs differential expression was significant and consistently increased in the most resistant genotype ICC3996 immediately following inoculation. Thus, they showed that the RGAs are key factors in the recognition of plant pathogens and the signaling of inducible defenses. These represent clear targets for future functional validation and potential for selective resistance breeding for introgression into elite cultivars.

Intracellular signaling mechanisms of RGAs in plant defense

TNL and CNL proteins recognize pathogen effectors that are secreted into the cell allowing plants to trigger the ETI response. *RIN4, PBS1, Pto* and *EDS1* are targeted and modified by numerous effectors and, as a result, their corresponding TNL or CNL will detect the modification to initiate ETI responses. Aside from targeting immune regulatory components, effectors can also target PTI/MTI signaling cascades. MAP kinase cascade, specifically *MPK4*, is capable of suppressing NBS-LRR protein *SUMM2* in absence of effector *HopAl1*. TIR-TIR interactions occur between *RPS4* and *RRS1* to further activate defense genes. Flg22, a bacterial PAMP, activates *FLS2* and *BAK1* RLKs to initiate the MAP kinase cascade that triggers PTI/MTI responses. MAP kinase cascade signaling can be interrupted by pathogenic effectors. When *MPK4* is compromised, *SUMM2* will not be inactivated and will initiate PCD.

Conclusions

RGAs are an efficient tool in identifying and isolating the disease resistant genes and have got efficiency in building durable resistance. Knowledge on a clear, functional mechanism of plant-microbe interaction and downstream pathways of disease resistant genes is moderate. The new, genomic, high approaches like Next Generation Sequencing (NGS) and other techniques, can pave the way for a better understanding of resistance mechanism in plants to pathogens. Comprehensive information and knowledge on RGA and genomic R loci architecture will help to develop multiple-disease resistance varieties or hybrids.

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Role of Plant Physiology in Production of Paddy

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Plant physiology plays a pivotal role in the production of paddy, also known as rice, one of the world's most crucial staple crops. This vital role encompasses a myriad of processes, all of which are interconnected and must function optimally to ensure a successful paddy crop. From germination to harvest, plant physiology influences every stage of the rice plant's life cycle, affecting its growth, yield, and overall quality. In this comprehensive exploration, we will delve into the intricate web of physiological processes that underlie paddy production, breaking down the role of plant physiology into several key areas.

Germination and Seedling Growth

The journey of a paddy plant begins with germination. The physiological processes that take place during this stage are fundamental to a healthy start. Water absorption, imbibition, and enzymatic activities play critical roles in breaking down stored nutrients in the seed and initiating growth. Water uptake swells the seed, causing it to rupture and release the embryonic plant. As the root emerges, it anchors the seedling into the soil, while the shoot elongates to reach the surface. The success of these processes depends on factors like soil moisture, temperature, and seed quality.

Photosynthesis

Photosynthesis is the heart of plant physiology and, in the context of paddy production, a key driver of crop success. In this process, chlorophyll-containing cells in the plant leaves capture sunlight to convert carbon dioxide and water into glucose and oxygen. For rice plants, photosynthesis ensures a consistent supply of energy and organic compounds needed for growth. Factors like light intensity, carbon dioxide availability, and leaf area index influence the rate of photosynthesis, which, in turn, impacts rice yield.

Water Uptake and Transpiration

Rice is known for its preference for flooded or waterlogged conditions. The physiological mechanisms behind this preference are unique and vital to its cultivation. Root structures known as aerenchyma facilitate efficient oxygen exchange between the roots and the surrounding waterlogged soil. This adaptation allows the plant to survive and thrive in flooded fields. Simultaneously, the rice plant loses water through transpiration, a process influenced by factors such as temperature, humidity, wind, and soil moisture. Regulating this water balance is crucial to avoid drought stress or excess water uptake, which can lead to diseases and reduced yield.

Nutrient Uptake and Transport

The acquisition of essential nutrients from the soil is another critical aspect of plant physiology in paddy production. Macronutrients like nitrogen, phosphorus, and potassium, along with micronutrients such as iron and zinc, are essential for the rice plant's growth. Root physiology plays a key role in nutrient uptake, with root architecture and symbiotic relationships with mycorrhizal fungi influencing the efficiency of nutrient absorption. Once absorbed, these nutrients are transported throughout the plant to various tissues, promoting root and shoot growth, flowering, and grain filling.

Flowering and Reproduction

The timing and success of flowering in rice are intricately linked to plant physiology. Photoperiod sensitivity in different rice varieties influences when they flower. Short-day varieties flower as days get shorter, while long-day varieties flower when days are longer. Additionally, hormonal signaling, especially involving gibberellins and abscisic acid, plays a significant role in controlling flowering. Pollination, typically facilitated by wind, is crucial for rice grain formation. Any disruptions in these physiological processes can lead to reduced grain set and, consequently, lower yields.

Grain Development and Filling

The final phase of a paddy's life cycle is the development and filling of grains. During this stage, plant physiology is heavily focused on ensuring optimal resource allocation. The plant diverts energy and nutrients towards grain development, impacting grain size and quality. Hormones like cytokinins and auxins influence this allocation, stimulating cell division and expansion in the grain. Proper regulation of this process is vital for achieving desired grain size, weight, and overall crop yield.

Responses to Environmental Stress

Paddy fields are subject to various environmental stressors, including diseases, pests, and adverse climatic conditions. Plant physiology is crucial in understanding how rice plants respond to these stressors. Defense mechanisms include the production of secondary metabolites, activation of resistance genes, and the synthesis of antimicrobial compounds. Understanding the physiological responses of rice plants to stressors is essential for developing effective pest and disease management strategies.

Harvest and Post-harvest Physiology

The physiological state of the rice plant at the time of harvest can significantly impact grain quality. Harvesting at the right stage of grain maturity is crucial to ensure optimal grain quality, taste, and storage life. Post-harvest physiology involves understanding the changes that occur in the grain after harvesting, such as respiration, moisture content, and nutrient composition. Proper drying and storage techniques are essential to preserve the quality of the harvested grain.

Modern Techniques and Genetic Improvements

Advancements in plant physiology research have enabled scientists to understand the physiological processes of rice plants at a molecular level. This knowledge has paved the way for genetic improvements and biotechnological interventions to enhance traits such as disease resistance, nutrient uptake efficiency, and drought tolerance in rice varieties. The Green Revolution, for instance, brought about high-yielding varieties of rice through physiological insights and breeding programs.

In summary, plant physiology is the underlying framework that sustains the entire lifecycle of paddy production. From the moment a seed germinates in the soil to the final harvest of mature grains, physiological processes dictate growth, development, and responses to environmental challenges. These processes are influenced by a complex interplay of environmental factors, genetics, and agricultural practices. A thorough understanding of plant physiology is essential for farmers, researchers, and policymakers seeking to improve paddy production, enhance crop resilience, and ensure food security for growing populations around the world.

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Fungal Effectors and Plant Susceptibility

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Abstract

Plant fungal pathogens are primary causal agents of many crop diseases of economic significance and pose serious threats to crop production and yield worldwide. Effector proteins are defined as small secreted proteins containing ≤300 amino acids. Many of these proteins are cysteine rich, and their tertiary structures are stabilized by disulfide bridges. The effectors are important virulence determinants of pathogenic fungi and play important role in successful pathogenesis, predominantly by avoiding host-surveillance system. As plant-pathogen interactions evolve, plants are selected for an incompatible (resistant) interaction and parasites are selected for a compatible (susceptible) interaction. The underlying principle for this antagonistic coevolution is based on the gene-for-gene model, arms race model, trench warfare model, zig-zag model. Effector evolution is a trade-off between escaping from detection and optimizing the virulence function. Compared with the avirulence function of effectors, a molecular understanding of the virulence and symbiosis-promoting activities of fungal effectors is still in its infancy. It is conceivable that fungal effectors may also be used to combat other microbes rather than being exclusively addressed toward plant targets.

Introduction

Plant fungal pathogens are primary causal agents of many crop diseases of economic significance and pose serious threats to crop production and yield worldwide. Effector proteins are defined as small secreted proteins containing ≤ 300 amino acids. Many of these proteins are cysteine rich, and their tertiary structures are stabilized by disulfide bridges. The effectors are important virulence determinants of pathogenic fungi and play important role in successful pathogenesis, predominantly by avoiding host-surveillance system.

Fungal plant pathogens are of huge economic importance because they threaten the production of crops already growing in the field and can cause post-harvest diseases. Estimates suggest that approximately 10 per cent of agricultural production is lost annually owing to fungal infection. With the growing consequences of climate change, these losses are expected to increase. To combat fungal infections, farmers rely on resistant crop varieties or multiple fungicide treatments, which can have negative effects on the environment. In addition, current agricultural practices that rely largely on planting one crop genotype on huge areas of land promote the selection of fungal strains that overcome genetic resistance quickly, necessitating the constant development and introduction of new resistance traits into crops by breeding approaches.

Interestingly, several targeted TFs are connected to plant growth and development. For instance, *P. infestans* AVR2 upregulates potato TF StCHL1, a positive regulator of the brassinosteroid (BR) signalling pathway. AVR2 expression in potato plants alters growth morphology, induces BR-marker gene expression and enhances susceptibility to *P. infestans* (Turnbull *et al*., 2017).

Depending upon the localization within the host, fungal effectors are broadly categorized into apoplastic and cytoplasmic effectors. Apoplastic effectors are secreted into the intercellular spaces (apoplast) of host tissue, while cytoplasmic effectors get directly translocated into the host cytoplasm (Rocafort *et al.,* 2020).

Knowledge about functions and double-edged role of fungal effectors of biotrophic, hemibiotrophic and necrotrophic pathogens, are crucial for understanding their mode of colonization and role in virulence/avirulence functions. This helps in effective management of fungal diseases in crop plants (Pradhan *et al.,* 2020).

Intracellular effectors of oomycete pathogens, mostly proteins but also small ribonucleic acids, are delivered by the pathogens into the host cell cytoplasm where they interfere with normal plant physiology. The diverse host processes emerging as 'victims' of these 'specialised bullets' include gene transcription and RNA-mediated silencing, cell death, protein stability, protein secretion and autophagy. Susceptibility factors are mostly negative regulators of immunity, but some seem necessary to sustain or promote pathogen colonization (Fabro, 2022).

Plant immune system: zig zag model

All fungi that colonize plants are recognized by the plant immune system and elicit host defenses. These initial defense responses are triggered by invariant molecular patterns exposed by the microbe, referred to as pathogen-associated molecular patterns (PAMPs) and microbe-associated molecular patterns (MAMPs). In fungi, the cell wall component chitin functions as such a PAMP: After fungal contact, chitin oligomers are released from the fungal cell wall through plant chitinases. PAMPs are recognized through membrane localized pattern recognition receptors (PRRs), which trigger a first line of defense reactions called PAMP-triggered immunity (PTI) (Presti *et al.*, 2015). PRR signaling can also be triggered by host-derived damage-associated molecular patterns (DAMPs).

Double facet functions of AVR4 effector

Knowledge about functions and double-edged role of fungal effectors of biotrophic, hemibiotrophic and necrotrophic pathogens, are crucial for understanding their mode of colonization and role in virulence/avirulence functions. This helps in effective management of fungal diseases in crop plants. Phyto-pathogenic fungi can cause huge damage to crop production. During millions of years of coexistence, fungi have evolved diverse life-style to obtain nutrients from the host and to colonize upon them. They deploy various proteinaceous as well as non-proteinaceous secreted molecules commonly referred as effectors to sabotage host machinery during the infection process.

Conclusion

Fungal effectors have evolved in variety and capability to target multiple plant proteins and mRNAs located in different compartments of the plant cell. Effector targets can influence plant defence either directly or indirectly, as well as positively or negatively. While some effectors alter main defence components (*e.g.,* ACS, NPR1), others disturb the activity of proteins that appear to be collaterally connected to defence execution, such as those participating in transcriptional regulation of growth/development or in protein degradation /secretion. A more subtle activity of effectors involves exploiting susceptibility factors (SFs), which are mostly negative regulators of immunity. SFs also include a subset of host proteins participating in processes (autophagy, RNAi, cell death, specific transcription) whose selective activation is required by the pathogen to maintain compatibility.

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Management of Flacherie Disease in Silkworm Rearing: A Devastating Disease at Present

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Diseases of silkworm are a big challenge for the rearers. Due to prolong domestication, silkworm develops less immunity and less adaptability for which they are often attacked by different pathogens leading to silkworm mortality and cocoon crop loss. In the recent days, silkworms are highly susceptible to flacherie disease due to favorable environment for the pathogens. Hence, effort has been made here to make understand the causes, causative agent, period of occurrence, source of infection, predisposing factors, symptoms of damage and most importantly its management.

Causes

- Physiological weakness of silkworm combined with the pathogenic/non-pathogenic microbes is the primary cause of Flacherie disease in silkworm.
- The adverse environmental conditions during silkworm rearing, starvation of silkworm, feeding of silkworms with poor nutritive quality of mulberry and improper handling of silkworm during the rearing are the causes for weakness in silkworms.
- The physiological weakness in silkworms makes them susceptible to pathogenic microbes.
- In such physiologically weak larvae, even the non-pathogenic bacterial micro flora of the mid gut multiply at faster rate, alter the gut environment and penetrate to haemolymph and cause flaccidity.
- Improper handling of silkworm leads to physical injury. The wound gets infected with microbes leading to Flacherie.

Causative agent

The main causative pathogens are Infectious Flacherie Virus (BmIFV), Densonucleosis virus (BmDNV) and bacteria such as *Streptococcus sp.*, *Staphylococcus sp.*, *Bacillus tlruringiensis* and *Serratia marcesence*. Flacherie is also caused by the combined infection of bacteria and viruses.

Flacherie infected larvae

Occurrence

The disease prevails all through the year but its severity is more during summer and rainy season.

Source of infection

By eating contaminated mulberry leaf. Dead/diseased silkworm, its faecal matter, gut juice, body fluid forms the source of contamination. The infection can also takes place through injuries, cuts and wounds.

Predisposing factors

Fluctuations in temperature, high humidity and poor quality of leaves.

Symptoms

- At the early stage of infection, symptoms are not clear and difficult to identify.
- The larvae become soft and flaccid.
- The growth of affected larvae retards, become inactive and vomit gut juice.
- The faeces become soft with high moisture content. Sometimes chain type of excreta is observed. Often, rectal protrusion is also observed.
- Cephalothoracic region becomes translucent.
- When infected with *Bacillus thuringiensis*, symptoms of toxicity such as paralysis and

sudden death are observed. After death larvae turn black in colour and give foul smell.

- Sometimes, the dead larvae turn red when infected with *Serratia marcescence* during injury.

Management

- Procure silkworm eggs produced from healthy parent moths so that the progeny would be least susceptible to microbial infections.
- Ensure meticulous disinfection of silkworm rearing house, appliances and the surroundings of the rearing house and use quality disinfectants at recommended concentration, quantity and schedule. Ensure rearing and personal hygiene during the rearing.
- An additional disinfection with 0.3% slaked lime solution is also recommended in case of high incidence of viral flacherie noticed in the previous crop.
- Feed silkworm with quality mulberry leaves, so that they grow physiologically strong and express high level of resistance to microbial infection. Provide quality leaf grown under good sunlight and recommended inputs. Do not provide over matured/ over stored / soiled leaves to the silkworm.
- Rear silkworms under recommended optimum temperature and humidity conditions so that the larvae grow healthy and resistive to infection. Avoid rearing silkworms under fluctuating temperature and humidity. Such conditions make silkworm weak and lose ability to resist infection.
- Never feed the silkworms with mulberry sprayed with insecticides/pesticides before the completion of the recommended 'safe period'. The silkworms fed on such leaves develop flacherie symptoms.
- Avoid overcrowded rearing of silkworm. It leads to larval starvation, undesirable environmental condition, resulting in loss of resistance to infection. Provide good cross ventilation in the rearing room.
- Avoid feeding excess mulberry leaves, which may lead to accumulation of uneaten leaves. The uneaten leaves as well as accumulated faeces ferment leading to increased bed temperature and humidity and make silkworm weak and lose resistance to infection.
- Avoid improper handling of silkworm causing injury especially during feeding, bed extension and mounting.
- Pick up suspected diseased larvae as early as possible and dispose them by burning/burying.
- Dust bed disinfectant, Ankush or Vijetha or as per the recommended schedule and quantity.
- Feed Amruth (Nandi Amruth or Rainbow Amruth) as per recommended schedule and quantity to control flacherie disease in silkworm.

Note: **AMRUTH** - An Eco and user-friendly botanical based formulation for suppression/ control of Grasserie and Flacherie diseases. The first ever curative formulation against silkworm diseases. Mix Amruth powder in water @20g/lit.

Schedule	Qty of Amruth (g)	Qty of water (ml)	Qty of leaf/shoot (kg)
After 2nd moult 2nd feed	7	350	5
After 3rd moult 2nd feed	53	2650	38
After 4th moult 2nd feed	90	4500	67

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Scenario of *Fusarium* Wilt of Chilli in India and Its Integrated Disease Management

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Abstract

Chilli (*Capsicum annum* L.) is one of the most important vegetable and spice crop belongs to family Solanaceae and genus *Capsicum*. India is the leading producer and consumer of chilli in the world. It is susceptible to several diseases and pests, which become major constraints in its production. Among them *Fusarium* wilt has emerged as a serious problem in past decade. Variable symptoms are observed which includes vein clearing, leaf epinasty, chlorosis, necrosis, abscission and wilting. The characteristic symptoms of the disease are brown vascular discoloration followed by upward and inward rolling of the upper leaves and subsequently wilting of the plants. The cultivation of resistant varieties is the most effective, economical and environmentally safe method for controlling plant diseases. Cultural practices offer an opportunity to alter the environment, the condition of the host and the behavior of pathogenic organisms in ways that adequately controls a particular disease. The biological management of plant pathogens is assuming significance on account of ill-effects of chemical fungicides and has become quite popular strategy to manage especially those diseases which are soil borne in nature and difficult to manage chemically. Chemical management is often the most feasible means of tackling a plant disease problem. Pathogens which are mainly soil and/ or seed borne, disinfection of seeds and soil with chemicals / fungicides has yielded encouraging results. Integrated disease management attempts to use all the known suitable techniques of control to maintain the particular pest population at a level below that which causes economical losses to the crop.

Introduction

Chilli (*Capsicum annum* L.) is one of the most important vegetable and spice crop belongs to family Solanaceae and genus *Capsicum*. It is grown for its green and ripe red fruit which is an indispensable condiment, digestive stimulant as well as flavoring and coloring agent in sauces, chutneys, pickles and other forms of food. India is the leading producer and consumer of chilli in the world. It is susceptible to several diseases and pests, which become major constraints in its production. Among them the most devastating are fungal diseases which lower the yield considerably annually. Leonian (1919) first time reported the wilt disease of chilli caused by *Fusarium* spp. *Fusarium oxysporum, F. solani*, *F. moniliforme* and *F. pallidoroseum* have been reported as the wilt causing agents from chilli growing areas but in India *F. oxysporum* and *F. solani* are the most prevalent species of *Fusarium* found associated with wilt disease of chilli (Naik, 2006). It has got great importance as it is having health benfits to mankind, with richness in antioxidants, vitamins like A, E, C and minerals like Ca. It also has anti-inflammatory and antibacterial properties so helping human beings in improving vision, boosting immunity, maintain digestive health of animals, keeping the skim radiant and young and giving soothing effects to respiratory system. Thus, it gained popularity.

Recently, anthracnose and *Fusarium* wilt becoming major yield declining fungal diseases. In India, wilt alone reducing the yield by 5 – 80 %. So it is a major problem, got attention by researchers as a epic work needed care to maintain the economy of the farmers with improved quality.

Symptomatology

Variable symptoms are observed which includes vein clearing, leaf epinasty, chlorosis, necrosis, abscission and wilting (Fig1). Symptoms are characterized initially by slight yellowing of the older leaves followed by younger leaves; the leaves became chlorotic and desiccated and the whole plant wither and die slowly. At first, the lower leaves and then upper leaves show loss of turgidity. Thereafter, stem shrivels and entire plant wilts. By the time above-ground symptoms are observed, the vascular system of the plant is discolored, particularly in the lower stem and roots.

Epidemiology

The pathogen become active in favourable conditions like, dry weather and excess soil moisture with soil temperature around 23 - 30°C. The chlamydospores present in the soil start germinating in response to the root exudes produced from the chilli plants. The germinating germ tube will directly penetrate into root tip or damaged root hair then it invades the root cortex by covering maximum inter cellular space of the root.

IDM strategies

Once a field is infested, the pathogen may survive in the soil for many years, fungus can be transported by farm equipment, drainage water, wind, or animals, including humans and warmer and drier climates (>25C) favour disease and also when crop rotations are not practiced (Khan *et al*., 2018).

The cultivation of resistant varieties is the most effective, economical and environmentally safe method for controlling plant diseases. Because of the soil borne nature of wilt pathogens, cultivation of resistant genotypes, if any, is best way of managing the problem. Various chilli wilt resistant varieties available are Musalwadi, Arka Lohit, Pusa Jwala, Pant C-2 and Jwahar-218 (Nayeema *et al*., 1995).

Cultural practices offer an opportunity to alter the environment, the condition of the host and the behavior of pathogenic organisms in ways that adequately controls a particular disease. *Fusarium* wilt of chilli can be successfully managed by sowing plants on ridges and avoiding excessive irrigation as wet soils were found to favour the disease. Higher pH levels are known to restrict the growth and development of *Fusarium* spp. in soil and hydrated lime has often been used for the purpose. Soil solarization can also reduce the population of *Fusarium oxysporum* f. sp. *capsici* up to 0-15 cm depth in soil (Leonian, 1919).

The biological management of plant pathogens is assuming significance on account of ill-effects of chemical fungicides and has become quite popular strategy to manage especially those diseases which are soil borne in nature and difficult to manage chemically. *Trichoderma viride* and *T. harzianum* has been found as potent biocontrol agents against *Fusarium* wilt in chilli. The application of endophytic bacteria *Bacillus subtilis* and rhizobacteria *Pseudomonas fluorescens*, singly and in combination were found to be effective in controlling the *Fusarium* wilt of chilli disease by inducing systemic resistance (ISR). Also, the plant extracts (*Eucalyptus citriodora*) and essential oils (neem and garlic oil) provide an effective measure for *Fusarium* wilt disease management and it represents an alternative to reliance on fungicides (Joshi *et al*., 2012).

Chemical management is often the most feasible means of tackling a plant disease problem. Pathogens which are mainly soil and/ or seed borne, disinfection of seeds and soil with chemicals / fungicides has yielded encouraging results. Seed treatment with fungicides like carbendazim 50 WP or captan 50 WP or thiram 75 DS at 2.5 g/kg seed before sowing, besides, seedling dip in carbendazim 50 WP (0.1 %) or benlate (0.05 %) or captan (0.2 %) for 30 minutes before transplanting has been found effective in managing the wilt disease of chilli. Applying fungicides as a drench around the stem of plants at the time of transplanting and again at 50 % flowering stage was found to be effective than using foliar sprays against wilt disease (Nelson *et al*., 1981).

Conclusion

The routine application of fungicides for insurance purposes is not appropriate, as it does not focus the proper attention on the real problem and can lead to resistance and potential environmental issues. Integrated disease management attempts to use all the known suitable techniques of control to maintain the particular pest population at a level below that which causes economical losses to the crop. Added benefits of IDM are that disease control is greater than that achieved by individual method. In the present experiment, we found that a significant increase in per cent germination and other plant growth parameters along with least disease incidence and highest yield in module-III (adoptive module) where we integrated both chemicals, bio control agents and soil amendments. This module found best for two seasons in two different locations of Karnataka. The cost economics was also calculated and found that, highest cost benefit ratio was obtained by following the adoptive module. There was significant reduction in pathogen population was also recorded from both the locations when compared with control treatment.

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Secondary Metabolites of Microbials as Potential Agrochemicals

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Abstract

Microorganisms especially bacteria and fungi are promising sources of structurally diverse and potent secondary metabolites. Many of these bioactive compounds are used as microbial pesticides. There is a continuing demand for novel bioactive compounds for management of devastating pathogens of crops, which are insensitive or less sensitive to existing chemical pesticides. These are being introduced in new scenario of crop protection and currently several beneficial microorganisms are the active ingredients of a new generation of microbial pesticides. Microbes contain a virtually untapped reservoir of pesticides that can be used directly or as templates for synthetic pesticides. Several beneficial microorganisms have been foundto be the active ingredients of a new generation of microbial pesticides or the basis of many natural products of microbial origin. Numerous factors have increased the interest of the pesticide industry and the pesticide market in this source of natural products as pesticides. The potential bioactivity evident from the overview on secondary metabolites of microbes presented above brings out clearly their potential for use in pest control. Being environment friendly and less toxic to nontarget pests, these microbial pesticides emerge as a potential option for pest management and hence they can be exploited as a skeleton for the synthesis of new strategies.

Introduction

Agriculture has been a means of livelihood and a source of food since the dawn of human civilization. About one third of the total crop yield is lost due to insect pests, pathogens and weeds. The introduction of DDT in 1945 followed by the use of various other synthetic chemical pesticides has played a key role in the increase of agricultural productivity and protection of crops from pests and diseases. However, the indiscriminate use of synthetic pesticides leads to serious problems like pesticide residues in food products, environmental contamination and development of resistance in target organisms (Fig. 1). Use of chemical pesticides has developed an urgent need to look for an alternative method for pest control. There are many approaches used to minimize the application of agrochemicals (Fig. 2). The use of microbial pesticides employing microorganisms or their by-products seems to be one of the best alternatives.

Microbial Pesticides

Microbial pesticides comprise of microorganisms such as bacterium, fungus or virus as the combat weapon. The preference of using bio-pesticides over synthetic chemicals has been widely accepted for several reasons.

Microbial pesticides -Advantages

They are degradable and their toxicity to non-target animals and humans is extremely low. Their ecological advantages are that they tend to be highly selective, infecting or killing a very narrow range of target pests. Another important advantage of bio-pesticides is their lower resistance in the target pest populations.

Main classes of secondary metabolites

Bacterial secondary metabolites

- **Phenazine**
  - Pyocyanin -*Pseudomonas aeruginosa*.
- **Polyketides**
  - Avermectin - *Streptomyces avermitilis*.
- **Non ribosomal peptides**
  - Polymyxin - *Paenibacillus polymyxa*.
- **Ribosomal peptides**
  - Bacteriocins microcin V - *Escherichia coli*.
- **Alkaloids**

- Tetrodotoxin - *Pseudoalteromonas*

Fungal secondary metabolites

- **Polyketides**
  - Strobilurins - *Strobilurus tenacellus*
  - Griseofulvin - *Penicillium griseofulvum,*
- **Non ribosomal peptides**
  - Cephalosporin C -*Acremonium chrysogenum*
- **Terpenes**
  - Fumagillin -*Aspergillus fumigatus*

Rawat and Kumar (2023) observed that the immobilization of second-stage juveniles (J2) by the fungus *P. florida* was found inversely proportional to the time period of incubation. Whereas, the trapping of J2 by the fungus *P. florida* and the time period of incubation was found directly proportional. It was found that the paralysis of J2 decreased with the increase in dilutions of cultural filtrate. The overall increase in growth parameters of tomato and decrease in reproduction parameters of *M. incognita* was found in the treatment where 60g GM and 100g SMS was used per 2 kg of nematode infested soil.

Hohenbuehelia reniformes and *Pleurotus salmoneostramineus* showed the ability to immobilize and consume the pinewood nematode, *Bursaphelenchus xylophilus*. They also investigated the nematode-trapping ability of the most effective nematode scavenger, *P. salmoneostramineus*. Nematode-trapping structures with abundant toxin droplets were observed on the surface of the mycelia, and more than half of the inoculated nematodes were immobilized by this strain within 24 h. The nematophagous activity of this strain was greater than that of the well-known nematophagous species, *P. ostreatus* (Ishizaki *et al*., 2015).

Perumal *et al.* (2023) isolated entomopathogenic fungi from Palamalai Hills (India) using insect bait method. *Metarhizium majus* (MK418990.1) was identified using biotechnological techniques. Bag-formulated fungal conidial efficacy (2.5×10^3, 2.5×10^4, 2.5×10^5, 2.5×10^6, and 2.5×10^7 conidia/ml) was evaluated against third instar larvae of *Spodoptera frugiperda* at 3, 6, 9, and 12 days of treatment. Study suggested that higher concentration (2.5×10^7 conidia/ml) of *M. majus* was efficient to cause 100% mortality at 9 days post treatment. Further investigation into enzymatic responses revealed that at 3 days post *M. majus* conidia exposure (2.5×10^3 conidia/ml), insect enzyme levels had significantly changed, with acid and alkaline phosphatases, and catalase enzymes significantly reduced and superoxide dismutase enzymes significantly raised relative to the control.

The endophytic fungus strain 0248, isolated from garlic, was identified as Trichoderma brevicompactum, from its culture extracts bioactive compound T2 was extracted which was identified as 4β-acetoxy-12,13- epoxy-Δ(9)-trichothecene (trichodermin) by spectral analysis and mass spectrometry. Trichodermin has a marked inhibitory activity on Rhizoctonia solani, with an EC50 of 0.25 µgmL(-1). Strong inhibition by trichodermin was also found for Botrytis cinerea, with an EC50 of 2.02 µgmL(-1). However, a relatively poor inhibitory effect was observed for trichodermin against Colletotrichum lindemuthianum (EC50 = 25.60 µgmL(-1)). Compared with the positive control Carbendazim.

Madhavi *et al.* (2011) studied compatibility of *Trichoderma viride* with 25 pesticides *in vitro*. Among six seed-treatment chemicals tested, *T. viride* showed a high compatibility with the insecticide Imidacloprid (7.6cm mycelial growth), followed by Mancozeb (6.3cm) and Tebuconazole (3.7cm). Contact fungicides, *viz.*, Pencycuron and Propineb were found to be fully compatible with *T. viride*. Among the 10 herbicides also tested, the fungus was highly compatible with Imazathafir (9.0cm) followed by 2,4-D Sodium salt (8.9cm) and Oxyfluoforen (6.5cm) while being totally incompatible with systemic fungicides like Carbendazim, Hexaconazole, Tebuconazole and Propiconazole.

Yashaswini *et al.* (2022) reported that *Bacillus sp.* an endospore-forming phyllosphere bacteria isolated from *Amaranthus spp.* showed antagonistic activity against *R. solani in vivo* (Dual culture plate assay and detached leaf assay) *and in vitro* (Greenhouse experiment) studies. Treatments included foliar spray on leaf blight susceptible red amaranthus variety Arun with cell suspension of bacterial isolates and the recommended fungicide Mancozeb (0.2%), pathogen inoculated control and absolute control. *Bacillus* sp. AL3 obtained from the red amaranthus variety Arun exhibited 44.5 % disease suppression over the pathogen inoculated control. Foliar spray with the recommended fungicide, mancozeb (0.2%), performed poorly in suppressing the disease compared to foliar application of bacterial cell suspension except for a single strain.

Conclusion

The unscrupulous use of chemical pesticides has led to widespread contamination of water, food and environment. Hence the use of microbial pesticides employing microbes or their by-products has found a potential role in the pesticide market. Microbes contain a virtually untapped reservoir of pesticides that can be used directly or as templates for synthetic pesticides. Several beneficial microorganisms have been found to be the active ingredients of a new generation of microbial pesticides or the basis of many natural products of microbial origin. Numerous factors have increased the interest of the pesticide industry and the pesticide market in this source of natural products as pesticides. The potential bioactivity evident from the overview on secondary metabolites of microbes presented above brings out clearly their potential for use in pest control. Being environment friendly and less toxic to nontarget pests, these microbial pesticides emerge as a potential option for pest management and hence they can be exploited as a skeleton for the synthesis of new strategies.

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Agro-Tourism Under Agricultural Extension Activity: A Journey into the Bountiful Countryside

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Agro-tourism is a popular form of tourism that allows visitors to experience the beauty of agriculture firsthand. From visiting working farms to participating in agricultural activities, agro-tourism offers a unique and immersive experience for travellers. This form of tourism has gained popularity in recent years, as more people seek authentic and immersive experiences away from the hustle and bustle of city life. In this article, we will explore the role of agro tourism under agricultural extension activity and the benefits it brings to both farmers and tourists. India, a land of diverse cultures, stunning landscapes, and rich heritage, offers a unique experience for travellers seeking to explore offbeat destinations. One such hidden gem is agro-tourism in India. This rapidly growing concept allows tourists to delve into the heart of rural India, immersing themselves in the traditional farming lifestyle while enjoying the warmth and hospitality of the locals. In this article, we will uncover the charms of agro-tourism and explore the role of agro-tourism under agricultural extension activity and the benefits it brings to both farmers and tourists.

What Exactly is Agro-tourism?

Agro-tourism, also known as agricultural tourism, is a form of tourism that takes visitors to rural areas to experience farming activities, stay in farmhouses, and engage with the farming communities closely. It offers a chance to disconnect from the fast-paced city life and connect with nature, gaining an insight into the agricultural practices, traditions, and sustainable farming methods. Agrotourism destinations can range from family-owned farms to vineyards, orchards, animal sanctuaries, and agricultural parks.

The Benefits of Agro-tourism

Agro-tourism not only provides a unique travel experience but also brings several benefits to the local economy and environment. Here are a few reasons why agro-tourism is gaining popularity:

India, with its vast agricultural landscape and diverse farming practices, holds immense potential for agro-tourism. From the lush tea gardens in Darjeeling to the fertile fields of Punjab, every region in India offers a unique experience. Here are a few reasons why you should consider agro-tourism:

Sustainable and Organic Farming: As the world shifts towards sustainable practices, agro-tourism in India emphasizes organic farming methods. It allows visitors to witness these sustainable practices firsthand, gaining knowledge about eco-friendly farming techniques that promote the well-being of both the environment and the consumers.

Escape to Serene Landscapes: Agro-tourism destinations in India are usually situated in picturesque rural settings, surrounded by lush green fields, rolling hills, and scenic landscapes. It offers a tranquil escape from the bustling cities and allows you to unwind, rejuvenate, and reconnect with nature.

Education and Awareness: Agro-tourism allows visitors to gain a deeper understanding of agriculture and its importance in our daily lives. It creates awareness about sustainable farming practices, biodiversity, and the challenges faced by farmers.

Supporting Local Economy: By visiting agro-tourism destinations, tourists contribute to the local economy. They purchase locally produced goods, support farmers and artisans, and indirectly create job opportunities in rural areas.

Preserving Traditional Culture: Agro-tourism promotes the preservation of traditional agricultural practices and cultural heritage. It helps in protecting local traditions, crafts, and cuisines. Agro-tourism provides an opportunity to witness the vibrant rural lifestyle of India. You can learn about the local customs, festivals, and traditional practices, contributing to a deeper understanding of the country's rich cultural heritage

Eco-Friendly Experience: Agro-tourism often emphasizes sustainable tourism practices such as organic farming, renewable energy sources, and recycling. This focus on eco-friendliness ensures that visitors have a minimal impact on the environment.

Activities in Agro-tourism

Agro-tourism offers a wide range of activities that engage and educate visitors. Some popular activities include:

Fruit Picking: Visitors can engage in fruit-picking activities in orchards, experiencing the joy of harvesting fresh produce. This hands-on experience is not only enjoyable but also allows tourists to support local farmers.

Farm Stays: Farm stays provide an opportunity to get a taste of rural life by staying on a working farm. Visitors can participate in daily farm activities, such as milking cows, herding animals, and cultivating crops.

Farm-to-Table Experiences: Agro-tourism often includes farm-to-table dining experiences, where visitors can savour fresh, locally sourced ingredients transformed into delicious dishes. This culinary journey allows travellers to appreciate the connection between agriculture and food.

Educational Workshops: Many agro-tourism destinations offer workshops and classes focused on agriculture. Visitors can learn about topics such as organic farming, cheese making, beekeeping, and wine production, gaining valuable knowledge from experts in the field.

The Emergence of Agro-Tourism

Agro-tourism has emerged as an innovative approach within the realm of agricultural extension. It offers a unique opportunity for farmers to diversify their income streams by opening their farms to tourists. Visitors get a firsthand experience of farming activities and rural life, while farmers generate additional revenue. This symbiotic relationship between farmers and tourists has paved the way for the growth of agro-tourism as a viable business model.

1. **Farm Viability:** Agro-tourism can help farmers overcome the challenges Benefits to Farmers:
2. **Diversification of Income:** Agro-tourism allows farmers to generate income from non-traditional sources. By opening their farms to tourists, they can create additional revenue streams that are not dependent solely on agricultural produce.
3. **Enhanced Networking and Collaboration:** Through interaction with tourists, farmers can establish networks and collaborations with other agricultural stakeholders. This can lead to knowledge-sharing, joint ventures, and access to new markets and technologies.
4. **Increased fluctuating agricultural market**: By diversifying their income, farmers can stabilize their financial situation and improve the overall viability of their farms.

Benefits to Tourists

1. **Educational Experience:** Agro-tourism provides an educational experience for visitors, allowing them to learn about various agricultural practices, livestock management, and crop cultivation. This hands-on learning experience fosters a deeper understanding and appreciation for the hard work and skills required in farming.
2. **Connection with Nature:** Agro-tourism offers a chance for tourists to reconnect with nature and experience the tranquillity of rural life. Away from the noise and pollution of the cities, visitors can enjoy the beauty of natural landscapes and engage in activities such as fruit picking, animal feeding, and nature walks.
3. **Cultural Immersion:** Agro-tourism allows tourists to immerse themselves in local cultures and traditions. They can interact with farmers, participate in local festivals and ceremonies, and sample authentic regional cuisine. This cultural exchange enriches the

travel experience and creates lifelong memories.

Role of Agricultural Extension in Agro-Tourism

Agricultural extension plays a crucial role in the development and promotion of agro-tourism. Extension professionals provide farmers with the necessary guidance, training, and advice on how to set up and manage agro-tourism activities. They help in identifying potential attractions and activities that can be offered to tourists, as well as marketing strategies to attract visitors. By incorporating agro tourism into their extension activities, extension professionals contribute to the growth and sustainability of rural economies.

Conclusion

Agro-tourism under agricultural extension activity brings together farmers and tourists in a mutually beneficial relationship. It provides farmers with an opportunity to diversify their income and improves the viability of their farms. For tourists, agro tourism offers an educational, nature centered, and culturally immersive experience. With the support of agricultural extension, the potential for the growth of agro tourism is immense. It not only benefits the stakeholders involved but also promotes sustainable agricultural practices and preserves rural traditions and landscapes. So, pack your bags and embark on a unique journey through the world of agro tourism.

Agro-tourism in India opens the gateway to a world where you can escape the concrete jungles and embrace the simplicity of rural life. By choosing to explore the agro-tourism destinations in India, you not only support local farmers and sustainable practices but also create lasting memories and forge unique connections. So, pack your bags, set off on an agro-tourism adventure, and witness the vibrant countryside of India like never before.

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Indian Meat and Poultry Industry: Current Scenario and Opportunities

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Why India for Meat and Poultry Processing?

- India has the world's largest population of livestock.
- India produces around 5.3 million MT of Meat and 75 bn eggs annually.
- India is the largest producer of buffalo meat and 2nd largest producer of goat meat.
- Growing demand in Indian customers for safe, clean, and hygienic meat as well as meat products creates an opportunity for farm automation, logistics, abattoirs, cold storage, and processing infrastructure at the point of sale.
- The government of India has taken steps for the modernization of municipal abattoirs to provide safe and hygienic meat to consumers.
- The development of abattoirs-cum-meat processing plants with the latest technology has been significantly invested in by export-oriented enterprises.

Growth of Indian Poultry Industry

Christian missionaries were the first to advocate for scientific poultry rearing. With the introduction of the second five-year plan (1956–61), coordinated efforts to establish poultry in India were initiated for the first time in 1957. In India, hybrid layer strains started out in 1955, followed by broiler strains in 1961. Period between II and IV Five-Year plan - turning point in the history of poultry industry in India.

In order to acclimate imported high-quality stock to the particular location's specific agroclimatic conditions, regional poultry farms have been established in Bangalore, Mumbai, Bhubaneswar, Delhi, and Shimla as a part of an All-India Poultry Development Project. High egg producing strains were produced by Central Poultry Breeding Farms in Mumbai, Bhubaneswar, Chandigarh, and Hesaraghatta (Bangalore); whereas Chandigarh farm established for its well-known fast growing broiler strains. Research on poultry nutrition and breeding is currently coordinated through All India Veterinary and Agricultural Universities and is being carried out at several research institutes. Trading egg and meat from poultry at the national and regional levels is undertaken via NAFED, the National Agricultural Co-operative Marketing Federation of India.

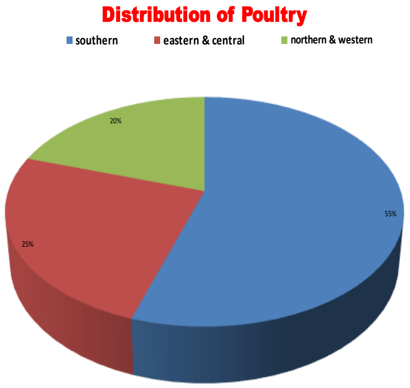
- Random Sample units at Hesaraghatta, Mumbai Bhubaneswar and Gurgaon.
- Central Training Institute for Poultry Production and Management at Hesaraghatta.

Strengths of Indian Poultry Industry

India stands out as a rapidly advancing economy, boasting the title of the world's fastest-growing economy. It leads globally in agricultural production across various commodities. Additionally, India ranks as the second-largest consumer market worldwide, driven by its sizable population. The country is strategically investing in top-notch ports, logistics, and supply chain infrastructure, showcasing its commitment to enhancing transportation and trade networks on a global scale.

India offers an investor-friendly environment with enticing incentives. It possesses a rich pool of highly skilled manpower. The government adopts proactive policies, contributing to a conducive business atmosphere. The country exhibits a significant consumer acceptance of eggs and broiler meat. Furthermore, advancements in Feed Conversion Ratio (FCR), stringent quality control, and enhanced management practices have led to improved efficiency and quality within the poultry industry.

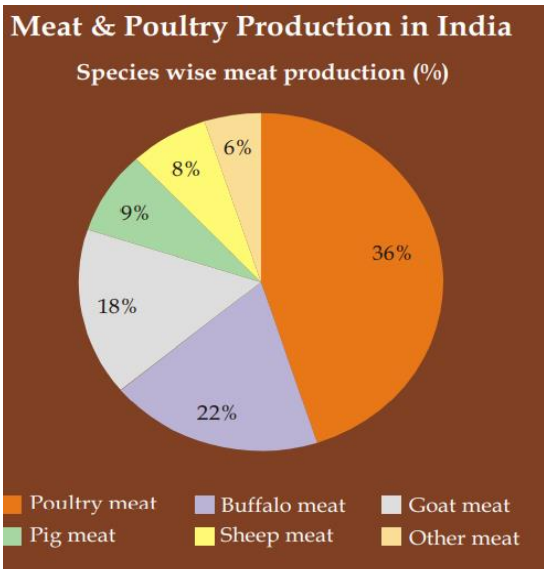
The poultry industry is benefitting from modern feed milling technologies, optimizing feed production. There's an emphasis on sourcing high-quality raw materials for feed, enhancing overall quality. The industry ensures better breeding stocks



with price assurance and rationalized pricing strategies. Pelleted feeds are gaining popularity in the market. Additionally, a variety of feed additives like enzymes, probiotics, prebiotics, and acidifiers are readily available. Integrators and corporates are playing a positive role in the industry's development. Feed units are strategically distributed across regions, improving accessibility and efficiency.

The poultry business has seen a rise in the production of processed foods, reflecting a shift towards value-added products. A streamlined and efficient transport system facilitates the movement of both raw materials and finished goods. Marketing efforts are focusing on promoting branded eggs, adding value to the products. The industry is exploring export opportunities to expand its market reach globally. Moreover, advancements in disease diagnosis and screening procedures are contributing to better health management and biosecurity within the industry.

Meat & Poultry Production in India



Species wise meat production (%)

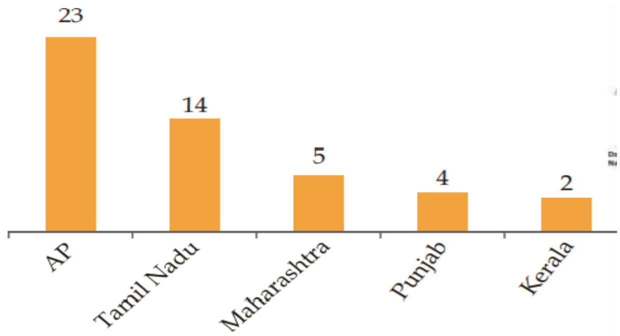
Source: Department of animal Husbandry, Dairying and Fisheries (DAHD)

Major States

Eggs

The top egg-producing states in India are Andhra Pradesh, Tamil Nadu, and Maharashtra.

Top 5 Egg Producers (in billion numbers)

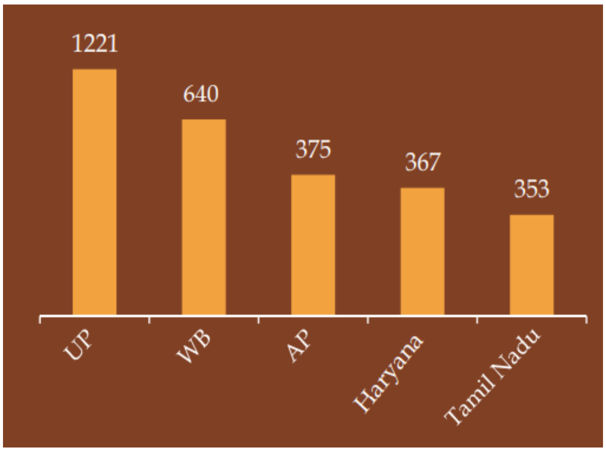


Source: Department of animal Husbandry, Dairying and Fisheries (DAHD)

Meat

Uttar Pradesh is the highest meat producer in the country which is contributing around 23% of the total meat production followed by West Bengal (12%) and Andhra Pradesh (7%).

Top 5 Meat producing states in India (production in 000'MT)

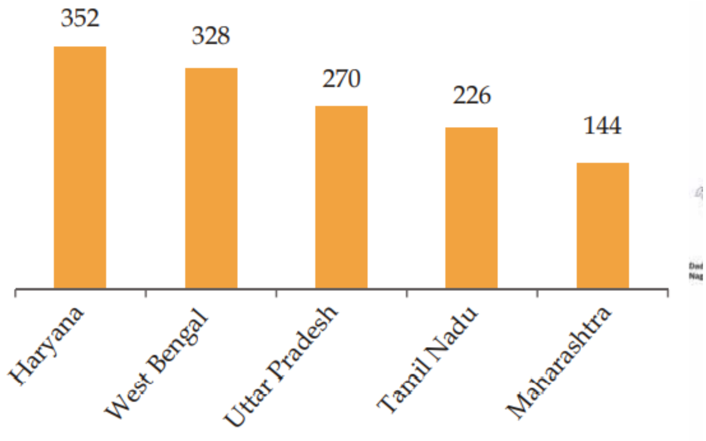


Source: Department of animal Husbandry, Dairying and Fisheries (DAHD)

Poultry Meat

India's leading poultry meat producing states are Haryana, West Bengal & Uttar Pradesh.

Top 5 Poultry Meat producing states in India (production in 000'MT)



Source: Department of Animal Husbandry, Dairying and Fisheries (DAHD)

Opportunities in Poultry & Meat Sector at a Glance

- **New technology in meat & poultry processing**

Recent emerging technologies such as Modern abattoirs, Food testing labs, Maintenance of Cold chain, and veterinary services.

- **Poultry Industry Players**

Egg powder plants, feed formulations and manufacturing operations, Hatcheries, New products with value addition like Indian ethnic snacks, frozen/chilled products, RTC/RTE.

Export Scenario

In 2014–15, India exported meat and poultry products valued at approximately USD 5 billion, of which USD 4.8 billion came from the export of buffalo meat alone. Egg powder, meat from sheep and goats, and other products are also exported. Vietnam, Malaysia, Egypt, Thailand and Saudi Arabia are major export destinations from India.

Key Fiscal Incentives

- In the food processing industry, 100% FDI is allowed via an automated way. The import benefits of the project pertain to imported equipment at a discounted price of customs duty. Income Tax deductions on capital expenditure allowed at the rate of 150% for setting up and operating cold chain or warehouse for storage of agriculture produce.
- For the first five years of operation, new food processing, preservation, and packaging facilities are exempt from income taxes at 100%; after that, they will pay income taxes at a rate of 25%–30%.
- The National Bank for Agriculture and Rural Development (NABARD) and the National Bank of India have established a fund of Rs. 20 billion to provide reasonably priced credit to approved Food Parks and their affiliated entities.
- The Ministry of Food Processing Industries (MofPI) offers several schemes, including the Mega Food Park Scheme, the Cold Chain Scheme, Value addition, Preservation Infrastructure, and the Scheme for Modernizing Government Abattoirs (with Different States Offering State-Specific Incentives).

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Drone Technology in Agriculture: Benefits and Challenges for Rural India

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The Indian economy is typically based on agriculture. For many rural households, agriculture continues to be their main source of income. A significant amount of India's exports are agricultural products, which are another important component of its economy. Despite the growing importance of agriculture, the industry is still lagging in terms of technical development. The main cause of this situation has been crop failure owing to unfavourable weather and unmanaged pest problems. Additionally, Indian farmers still rely on the monsoon rains for irrigation and employ traditional techniques for other aspects of farming. Thus, despite farmers' tireless efforts, the quality and quantity of agricultural produce are occasionally affected.

Drone technology has gained popularity recently in the agricultural industry. Farmers can earn profit by using drones in a variety of ways, such as higher productivity, increased yields, and lower expenses. There are worries, too, that farmers would be hesitant to use drone technology out of concern for their jobs or a lack of understanding and training. We may examine the advantages of drone technology for the agricultural industry as well as the difficulties that might prevent farmers from implementing this technology.

The Indian agriculture industry and drones

Unmanned aerial vehicles (UAVs), sometimes known as drones, are used for a variety of jobs, from routine to extremely dangerous. These robotic-looking planes can be seen practically everywhere, from delivering groceries to your home to rescuing avalanche victims. Up until recently, they were mostly utilized by businesses in the mining and construction industries, the military, and hobbyists. But now that drone technology is more widely accessible, it may also be used several agricultural areas. Though the technology is still in its infancy in India, numerous businesses are working to make it freely accessible to Indian farmers and prepared for use to boost agricultural production efficiency.

Agriculture drones can collect precise information about crop health, soil conditions, and other important characteristics. This information enables farmers to make wise choices regarding planting, irrigation, fertilization, and insect management, leading to more productive and economical farming methods. The significant advantages are:

- **Crop Monitoring**: Drones with cameras and sensors allow for real-time crop status monitoring. As a result, farmers are better able to identify problems like pests, illnesses, and nutrient deficits early on and take prompt corrective action.
- **Enhanced Productivity**: Farmers may optimize their agricultural techniques, which will enhance crop yields, using the insights gathered from drone data. Drones assist in identifying regions where crops may require attention, maximizing the land's output.
- **Reduced expenses**: Agricultural drones can result in cost savings by minimizing the requirement for physical labour and the abuse of resources like water and fertilizers. They also aid in lowering the possibility of human error in agricultural processes.
- **Climate Impact**: Precision agriculture using drones can lessen agriculture's environmental impact. It minimizes the detrimental influence on ecosystems and uses fewer chemicals by using resources more wisely and applying treatments only when necessary.
- **Time effectiveness**: Drones can quickly traverse huge farmed regions, making it possible to collect and check data more frequently. Compared to conventional inspection and data collecting procedures, this saves time.

- **Crop security**: Accurate and current data from agricultural drones might be useful for this type of insurance, enabling farmers to estimate crop damage and submit claims more accurately.
- Drones can be used in agricultural research and development to test novel crop varieties, irrigation strategies, and pest management techniques. This contributes to the advancement of agriculture by offering insightful information.
- **Accessibility:** A variety of farms, including small- and large-scale businesses, may now use drones because they are becoming more economical and user-friendly.
- **Remote sensing**: Drones with a variety of sensors, such as multispectral cameras and thermal imaging cameras, may collect data that is frequently hidden from view. This aids farmers in making informed decisions by providing information on plant stress, soil moisture etc.

Working system of drone technology

A navigation system, GPS, numerous sensors, high-quality cameras, programmable controllers, and tools for autonomous drones are typically included with drones. One such well-known drone used by the sector is the DJI. Currently, most farmers use satellite imaging as a basic management tool for their farms. With sophisticated equipment, unmanned aerial vehicles (UAVs) can obtain more exact data for precision agriculture than satellites. They then use agricultural technology tools to process the data collected and provide useful knowledge.

The steps involved in gathering data from an agricultural drone are as follows:

a) Changes to your text are highlighted in orange, and you can add more by clicking on individual words and changing them with synonyms. Test it out!

b) **Examining the region:** This identifies the testing territory. As a result, setting up a border, analysing the area, and ultimately transferring the technical GPS data into the drone's navigation system constitute the first phase.

c) **Autonomous drone data processing:** Since unmanned aerial vehicles (UAVs) are autonomous, they enter flight patterns into their pre-existing system to gather necessary data.

d) **Uploading the data:** After all the necessary data has been collected using sensors like multispectral and RGB sensors, it is processed using a variety of tools for additional analysis and interpretation.

e) **Output:** After gathering the information, they format it such that farmers can easily grasp it, advancing them towards precision farming. Using photogrammetry or 3D mapping, you may present a lot of acquired data.

Problems implementing drone technology in agriculture

While drones provide many benefits to farms, there are some obstacles that may prevent farmers from adopting this technology. Following are the major challenges:

1. Many farmers are concerned that the introduction of drone technology would result in job losses because fewer personnel will be required to undertake manual labour on the farm.
2. Lack of knowledge and training: Farmers may lack the requisite expertise and training to operate drones successfully. This may make it difficult for them to adopt this technology because they are unsure of their abilities to use it.
3. Drones can be costly, and many farmers may not have the financial means to invest in this technology.
4. Regulatory obstacles: Regulatory restrictions to the use of drones in agriculture may exist,

making it difficult for farmers to adopt this technology.

Drone technology penetration in the agriculture industry in rural India is still in its early stages. While this technology is gaining popularity, there are concerns about job loss and a lack of expertise and training. However, efforts are being made to address these issues and encourage the use of drone technology.

The Digital India programme, which aims to offer digital infrastructure and connection to rural areas, is one of the primary projects. This effort focuses on training and education, which may help to solve farmers' lack of knowledge and training.

Furthermore, there are several organisations and efforts encouraging the use of drone technology in agriculture. The Indian Council of Agricultural Research (ICAR), has developed a Centre for Precision and Farming Technologies to promote precision agriculture technologies such as drones.

Conclusion

Agricultural drone technology is unquestionably the future of the Indian agrarian sector. It has the potential to revolutionise traditional farming processes in an infinite number of ways. Even while this technique is more difficult to grasp, once mastered, it produces results quickly.

Farmers must understand the full procedure. For the collection of credible data, farmers must require extensive training or collaboration with third-party professionals in the drone business. Drones have altered the way data is collected in practically every business, and they will only get bigger and better in the future.

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Ditelosomic Alien Addition Lines in Plant Breeding

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Abstract

Genetic improvement in crops is essential for addressing agricultural challenges, including increased yields, disease resistance, and adaptability to diverse environments. A notable strategy in cytogenetics and plant breeding involves the transfer of alien genes through wide hybridization and chromosome manipulation, enabling the introduction of genetic material from wild species into cultivated crops. This transfer occurs at various levels, such as whole genome, whole chromosome, alien chromosome arms, and chromosomal segments. Ditelosomic Alien Addition Lines (DAALs) emerge as a powerful method, involving the addition of one or a pair of chromosomes from wild species to the cultivated species, leading to the development of distinct plant lines. The creation and identification of ditelosomic lines, exemplified by the development of barley chromosome ditelosomic addition lines in hexaploid wheat, require meticulous steps, including embryo culture and molecular analyses like Genomic In Situ Hybridization (GISH) and molecular markers. These ditelosomic lines, identified through methods like mitosis, karyotype analysis, and molecular markers, offer applications beyond development. Examples like the wheat-rye line WR56 demonstrate resistance to powdery mildew, showcasing the potential of ditelosomic lines in enhancing crop traits for sustainable and resilient agriculture.

Introduction

Genetic improvement in crops has been a longstanding goal in agriculture, driven by the need for increased yields, disease resistance, and adaptability to various environmental conditions. One of the remarkable strategies in the field of cytogenetics and plant breeding is the transfer of alien genes through wide hybridization and chromosome manipulation. Alien gene transfer involves the introduction of genetic material from related wild species into cultivated species, providing an avenue for enhancing desirable traits such as hardiness, earliness, disease resistance, and insect resistance. This transfer can occur at different levels, including whole genome transfer, whole chromosome transfer, alien chromosome arms transfer, and transfer of chromosomal segments.

Among the methods employed for alien gene transfer, Ditelosomic Alien Addition Lines (DAALs) stand out as a powerful tool. DAALs involve the addition of one or one pair of chromosomes from related wild species to the normal chromosomal complement of the cultivated species. In this context, ditelosomic lines, specifically, lack one pair of chromosome arms, leading to the development of plant lines with distinct genetic characteristics.

Development of Ditelosomic Addition Lines

The process of creating ditelosomic addition lines is intricate and requires a series of carefully orchestrated steps. For example, in the development of barley chromosome ditelosomic addition lines in hexaploid wheat cultivar "Asakaze," the Japanese facultative wheat Asakaze was used as the female parent, and the Ukrainian six-rowed winter barley Manas served as the pollinator. The resulting wheat-barley hybrid underwent embryo culture, tissue culture, and backcrossing to achieve stability and genetic uniformity. Subsequent analyses, including Genomic In Situ Hybridization (GISH) and molecular markers, were employed to identify and select the ditelosomic addition lines.

Friebe *et al.* (1999) production and identification of a complete set of intact *Aegilops geniculata* chromosome and telosome additions to common wheat. It included Thirteen disomic, one monosomic wheat-Ae. geniculata chromosome additions, two monotelosomic and nine ditelosomic lines. similarly. Jobba *et al.* (1975) produced durum line with 15 pairs of chromosomes is a 1D-disomic addition line. Seed from the 1D-disomic addition line produced two high-molecular-weight glutenin polypeptide subunits not present in durum wheats, as determined by sodium dodecyl sulfate-polyacrylamide gel electrophoresis.

Identification of Ditelosomic Alien Addition Lines

Several methods can be employed to identify ditelosomic alien addition lines, including mitosis, karyotype analysis, meiotic chromosome pairing, cyto-genetic studies, molecular markers, and morphology.

1. **Mitosis:** Mitotic analysis involves examining root tips from germinating seedlings, where the presence of an extra pair of telochromosomes can be observed in metaphase of mitotic cell division.
2. **Karyotype:** The arrangement of chromosomes in a karyotype reveals the presence of an additional pair of telochromosomes along with the complete set of chromosomes.
3. **Meiotic Chromosome Pairing:** Meiotic analysis, such as GISH, allows for the detection and visualization of rye chromatin in wheat-rye ditelosomic addition lines, confirming genetic stability.
4. **Molecular Markers:** The use of specific molecular markers, such as EST-SSR markers, can further validate the presence of alien chromosome arms in ditelosomic lines.
5. **Morphology:** Variations in plant and spike morphology provide additional insights into the genetic composition of ditelosomic addition lines.

Lin *et al.*, (2006) identified two ditelosomic additions and one disomic substitution line among the offspring of the plant derived from immature hybrid embryos of wheat–Thinopyrum intermedium disomic addition line Z6 common wheat variety Zhong8601, a plant with a telocentric chromosome. Two random amplified polymorphic DNA molecular markers were identified among 150 random primers used to detect the different arms of the alien chromosome. These might be useful for developing translocation lines with barley yellow dwarf virus (BYDV) resistance.

Bilgic *et al.* (2007) used the Affymetrix Barley1 GeneChip for comparative transcript analysis of the barley cultivar Betzes, the wheat cultivar Chinese Spring, and Chinese Spring – Betzes ditelosomic chromosome addition lines to physically map barley genes to their respective chromosome arm locations. They mapped 1257 barley genes to different chromosome arms based on their transcript levels in the ditelosomic addition lines. and also validated the physical locations of the genes through comparison with their previous chromosome-based physical mapping, comparative *in silico* mapping with rice and wheat, and single feature polymorphism (SFP) analysis. *In silico* comparative mapping of barley genes assigned to chromosome arms revealed that the average genomic synteny to wheat and rice chromosome arms was 63.2% and 65.5%, respectively. In the 1257 mapped genes, 924 genes identified were found between the appropriate ditelosomic line and Chinese Spring that supported physical map placements.

Applications of Ditelosomic Lines

Tan *et al.* (2021) characterized a novel wheat-*P. huashanica* line, DT23, derived from distant hybridization between common wheat and *P. huashanica*. Fluorescence *in situ* hybridization (FISH) and sequential genomic *in situ* hybridization (GISH) analyses indicated that DT23 is a stable wheat-*P. huashanica* ditelosomic addition line. FISH painting and PCR-based landmark unique gene markers analyses further revealed that DT23 is a wheat-*P. huashanica* 7Ns ditelosomic addition line. Observation of spike differentiation and the growth period revealed that DT23 exhibited earlier maturation than the wheat parents. Based on specific locus-amplified fragment sequencing technology, 45 new specific molecular markers and 19 specific FISH probes were developed for the *P. huashanica* 7Ns chromosome. Marker validation analyses revealed that two specific markers distinguished the Ns genome chromosomes of *P. huashanica* and the chromosomes of other wheat-related species. These newly developed FISH probes specifically detected Ns genome chromosomes of *P. huashanica* in the wheat background. The DT23 line will be useful for breeding early maturing wheat. The specific markers and FISH probes developed in this study can be used to detect and trace *P. huashanica* chromosomes and chromosomal segments carrying elite genes in diverse materials.

Turkosi *et al*. (2016) revealed that six-rowed winter barley cultivar Manas is much better adapted to Central European environmental conditions than the two-rowed spring barley Betzes previously used in wheat-barley crosses. The production of wheat-barley ditelosomic addition lines have a wide range of applications both for breeding (transfer of useful genes to the recipient species) and for basic research (mapping of barley genes, genetic and evolutionary studies and heterologous expression of barley genes in the wheat background).

An *et al.* (2022) produced wheat-rye line WR56 through distant hybridization, embryo rescue culture, chromosome doubling and backcrossing. WR56 was then proved to be a wheat-rye 2RL ditelosomic addition line using GISH (genomic in situ hybridization), mc-FISH (multicolor fluorescence in situ hybridization), ND-FISH (non-denaturing FISH), mc-GISH (multicolor GISH) and rye chromosome arm-specific marker analysis. WR56 exhibited a high level of adult plant resistance to powdery mildew caused by Blumeria graminis *f. sp*. tritici (Bgt). This resistance was carried by the added 2RL telosomes and presumed to be different from Pm7 which is also located on chromosome arm 2RL but confers resistance at the seedling and adult stages. WR56 will be a promising bridging parent for transfer of the resistance to a more stable wheat breeding line.

Conclusion

Ditelosomic alien addition lines represent a powerful tool in plant breeding, allowing for the transfer of desirable traits from wild species to cultivated varieties. Their applications range from disease resistance to environmental adaptability. The identification, development, and characterization of these lines involve a combination of cytogenetic and molecular techniques. As demonstrated by examples like WR56 and Manas barley chromosome additions, ditelosomic lines hold great promise for the development of improved crop varieties with enhanced traits, contributing to sustainable and resilient agriculture in the face of evolving challenges.

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Women Empowerment

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Women's empowerment refers to educating women in order for them to become financially independent and capable of making their own decisions. It also implies that they are protected against all forms of violence, regardless of discrimination. Women's empowerment can be characterized as boosting women's self-esteem, ability to make their own decisions, and right to influence societal change for themselves and others. Women's empowerment is a fundamental right. They can have equal access to education, society, economics, and politics. They are permitted to pursue higher education and are treated in the same manner as males.

In this article, you will know about the importance of women's empowerment. People that are empowered have authority and control over their own life. People receive the assistance they require that is appropriate for them. Empowerment means that people are equal citizens. They are well-liked and respected in their communities.

Benefits of Empowering Women in India

As a result, providing equal opportunities for women in India would enable them to contribute to the economy as productive citizens. Women can thrive economically and rise out of poverty with higher literacy rates and equal pay for equal work. We strengthen local economies, businesses perform better and families rise out of poverty to create generational wealth and self-sufficiency. Women's empowerment is critical for the health and social development of families, communities, and countries. When women live safe, fulfilled, and productive lives, they can reach their full potential in the workforce and raise happier and healthier children. Girls who receive an education are less likely to marry young and live healthier and productive lives. They earn higher incomes, participate in the decisions that most affect them and build better futures for themselves and their families. Girls' education strengthens economies and reduces inequality.

Government role in Women empowerment

The Government of India has taken various steps to ensure women's empowerment through social, educational, economic, and political upliftment through various schematic interventions. While the schemes implemented by the Government like Pradhan Mantri Awas Yojana (Urban & Rural), the National Social Assistance Programme (NSAP), the initiatives like Samagra Shiksha, Scheme of National Overseas Scholarship, Babu Jagjivan Ram Chhatrawas Yojna, Swacch Vidyalaya Mission, etc. ensure that schools are girl-friendly especially for vulnerable sections of society and have adequate facilities in place to fulfil their special requirements.

To improve female workers' employability, the government is training them through a network of Women Industrial Training Institutes, National Vocational Training Institutes, and Regional Vocational Training Institutes. The government has also launched the Skill India Mission to help women achieve economic independence through skill development and vocational training. The National Skill Development Policy emphasizes inclusive skill development with the goal of increasing female participation for increased economic productivity. The Pradhan Mantri Kaushal Vikas Kendras emphasize the creation of additional infrastructure for both training and apprenticeship for women; flexible training delivery mechanisms, flexible afternoon batches on local need-based training to accommodate women; and ensuring a safe and gender sensitive training environment, the employment of women trainers, equity in remuneration, and a complaint redressal mechanism.

There are programs in place to assist women in starting their own businesses, such as the Pradhan Mantri Mudra Yojana and Stand-Up India, as well as the Prime Minister's Employment Generation

Programme (PMEGP). The Pradhan Mantri Ujjwala Yojna (PMUY) aims to protect women's health by providing them with clean cooking fuel while also relieving them of the arduous task of collecting firewood. Further, the National Education Policy (NEP), 2020 prioritizes gender equity and envisions ensuring equitable access to quality education to all students, with a special emphasis on Socially and Economically Disadvantaged Groups (SEDGs).

Conclusion

Women empowerment's contribute to a better society and world a better place to live in and much forward on way to inclusive participation. It refers to increasing happiness in the family and in organizations where women make a difference. A woman is capable of doing everything a man does, and even more. One day, every woman in the country will be truly empowered.

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Pangenomics and Its Role in Plant Breeding

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Abstract

Genetic diversity, characterized by single-nucleotide polymorphisms (SNPs) and significant structural variations (SVs), plays a crucial role in shaping the gene content within a species. Pangenomic investigations reveal the impact of SVs on crop domestication, enhancement, and evolution, providing insights into a species' complete genomic repertoire. The pan-genome, comprising core and dispensable genes, unveils novel genes and alleles linked directly to phenotypes through a Pangenomic approach. Utilizing an iterative mapping strategy, a chickpea pan-genome captures genetic diversity across cultivated and wild accessions, identifying unique genes with defense and adaptation mechanisms. Similarly, rice pan-genome analysis highlights deletions in key genes contributing to blast resistance and environmental adaptation. Overall, pan-genomics enhances our understanding of genetic diversity, facilitating trait dissection, broadening access to genetic resources for breeding programs, and accelerating crop improvement strategies for creating resilient and high-yielding varieties.

Introduction

Single-nucleotide polymorphisms (SNPs) and big structural variations (SVs) are examples of genetic diversity that can result in differences in gene content between members of the same species. Pangenome study identifies structural variations (SVs) as having contributed to crop domestication, improvement, and evolution. The exploration of a species' complete genome repertoire is aided by pan-genome analysis.

An entire gene set from a biological group, such as a species, is referred to as a pan-genome. This gene set can be divided into a set of core genes that are shared by all individuals and a collection of dispensable genes that are either partially shared or individual specific (Tettelin *et al*., 2005). Finding new genes and alleles directly connected to phenotype using a Pangenomic method.

By using an iterative mapping strategy, a chickpea pan-genome was constructed to represent the genetic diversity found in both cultivated and wild accessions of the crop. 29,870 genes in total, 1,582 of which were unique genes with numerous defence and adaption mechanisms, were found. More gene-gain copy number variations (CNVs) and gene-loss CNVs have been found in C. reticulatum than in cultivated accessions, indicating a higher degree of divergence between wild and domesticated cousins (Varshney *et al*., 2021).

A pangenome analysis in rice revealed those two independent deletions in the OsWAK112d gene, which is a negative regulator of blast resistance in rice, contributed to environmental adaptation by improving blast resistance. This deletion is located 643 bp upstream of the OsGLP2-1 gene, which was shown to block seed dormancy and strongly increase seed dormancy upon overexpression. Additionally demonstrated that OsVIL1 copy number variation (CNV) is probably related to grain number and blooming period (Qin *et al*., 2021).

During tomato domestication and improvement, there was significant gene loss and strong negative selection of genes and promoters, according to presence/absence variation analyses of the tomato pangenome. discovered an uncommon allele in the TomLoxC promoter that is linked to the formation of apocarotenoid, which contributes to the desired tomato flavour and was selected against during domestication (Gao *et al*., 2016).

Brassica napus accessions were found to have presence and absence variations (PAVs) ranging from 77.2-149.6 metabases. In a nested association mapping population with ZS11 (the reference line) as the donor, PAV-based genome-wide association study (PAV-GWAS) directly identified causal structural variations for silique length, seed weight, and flowering time that were not detected by single-nucleotide polymorphisms-based GWAS (SNP-GWAS), demonstrating that PAV-GWAS was complementary to SNP-GWAS in identifying associations to traits (Ming *et al*.,2021).

Analysis of the genome Soybean revealed that genes producing an amino acid transporter, a -SNAP protein, and a WI12 (wound inducible protein) are involved in soybean cyst nematode (SCN) resistance in a 31 kb section at rhg1-b. Additionally, this segment's copy number variation improves the SCN resistance (Cook et al., 2016).

Conclusion

Overall, pan genomics aids in a better understanding of the genetic diversity of the gene pool which can facilitate trait dissection applications to identify structural variations, allow breeding programmes to access a wider range of genetic resources, aid in the adoption of the best breeding programme strategies, and ultimately accelerate crop improvement to create varieties with stab.

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Life Satisfaction and Happiness

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A state of well-being is happiness. It is the extent to which a person regards the whole quality of his existence with admiration, and it is commonly considered to be the ultimate goal in life. There are two ways that Aristotle's ideas about happiness are seen. Both traditions make an effort to differentiate between what they consider to be a good life. The main idea of the first view is that a happy life is defined by one's level of personal happiness (Ryan and Deci, 2001). Hedonistic thinking has been applied to this viewpoint (Kahneman, Diener & Schwarz, 1999). According to the second tradition, being happy alone does not constitute well-being. Instead, it is found in the realization of human potential (Waterman, 1993).

According to Csikszentmihalyi (1990), engagement (also known as an engaged life) is the second element of a happy life in Seligman's theory. It is a life that seeks participation and absorption in work, intimate relationships, and leisure. Flow is a phrase used by Csikszentmihalyi to describe extremely readable and captivating works. People who are in flow are deeply joyful, creative, and fully engaged in life. It is a condition of total immersion in a lighthearted or artistic endeavor. Time flies by quickly. The action has all of one's attention. One no longer feels like themselves.

Accomplishment: The fourth component of Seligman's well-being model that the genuine happiness model overlooked is accomplishment. He claims that people pursue success, accomplishment, achievement, mastery, and success for their shake in his well-being model. People work and play in order to pursue enjoyment, engagement, and delight, but they also have an underlying desire to succeed. According to Seligman, cultivating accomplishment either by itself or in conjunction with any of the other four elements will increase well-being (Seligman, 2012).

Positive relationship: In Seligman's theory of well-being, positive relationships make up the fifth element. This component recognizes the value of connections that flourish and a sense of connectivity in overall wellbeing. It is indisputable that the yearning for connection is a basic human need. One's relationships with coworkers, friends, family, and other people are a major source of harm to their wellbeing. Positive relationships satisfy two out of the three requirements for inclusion in the well-being theory. They can be examined separately from the other components and they enhance well-being (Seligman, 2012).

Two Luminous Traditions

Hedonistic customs

The concept of hedonic happiness originated with the teachings of Greek philosopher Aristippus in the fourth century B.C., who advocated that maximizing pleasure should be the ultimate aim in life. Hobbes and Jeremy Bentham are among the thinkers who have adhered to this hedonistic perspective throughout history. When examining happiness from a hedonic standpoint, psychologists create a broad umbrella by understanding hedonia as including both mental and physical pleasures. According to this perspective, happiness is essentially about avoiding pain and increasing pleasure.

Eudaimonic legacy

Although eudaimonic happiness is not as often studied in American society, it nevertheless has a substantial impact on our understanding of happiness and wellbeing from a psychological perspective. Similar to Sedona, Aristotle first articulated the idea of eudaimonia in his Nicomachean Ethics in the fourth century B.C. Aristotle thought that leading a moral life was the best way to achieve happiness. According to him, people are always trying to reach their full potential and be the best versions of themselves, which results in more purpose and meaning.

Current Concept of Happiness

Seligman (2002) divided happiness into three dimensions that may be controlled by science. These are happiness (a happy existence), engagement (a life that is engaged), and meaning (a life that has purpose). These are quantifiable, controllable, and accurately handled terms. Feelings of happiness (a pleasant life): The hedonic tradition of happiness speaks of the joyful life. According to Seligman et al. (2006), it entails cultivating a great deal of optimism about the past, present, and future as well as knowing how to intensify and prolong these feelings. Among the feelings associated with the past are pride, contentment, satisfaction, peace, and satisfaction. Joy that comes from a surprise happy moment is one example of a positive emotion regarding the present. Hope, optimism, faith, trust, and confidence are examples of positive emotions concerning the future.

Life satisfaction

Being objective beings, humans constantly assess the circumstances in their lives. Until he achieves his objectives, he will not feel satisfied. It's probably safe to say that every human being's ultimate ambition is to fulfill his or her own ambitions, since this leads to a happy existence. Life satisfaction is therefore a key component of human welfare. It is the ultimate objective, and all people work toward achieving it throughout their lives. While life satisfaction is the state of happiness that arises when we consider our lives as a whole, overall, happiness is an instantaneous, in-the-moment feeling. Living conditions, including food, health, housing, and other necessities, are related to the study of life satisfaction and quality of life (Veenhoven, 1996).

Life satisfaction refers to an individual's perception of their life thus far, as well as their feelings and thoughts for their future. It is a global, cognitive assessment as well as a well-being indicator. It involves adopting a positive outlook on life in general. A person's perception of their life and their feelings about its future direction are known as their life satisfaction. It is both a measure of wellbeing and a broad, cognitive conclusion. It involves adopting a positive outlook on life in general. The degree of education, experience, and economic standing have all been used to gauge life satisfaction.

Life satisfaction and Personality

According to Frisch (1999), life satisfaction may be a reflection of positive experiences that have inspired individuals to strive for and accomplish their objectives. There are two main emotions that influence how people view their lives. Both optimism and hope are products of cognitive processes that were initially focused on achieving and perceiving specific goals. Numerous research has demonstrated the clear influence that self-esteem has on life satisfaction. Additionally, a homeostatic model (Cummins et al., 2002) corroborates these findings. A person's viewpoint in life can also have an impact on how satisfied they are with their life.

Life satisfaction and values

A person's values and the things that are significant to them shape their life. According to these principles, an individual's source of life happiness is internal. Individual differences exist in the personal values and priority that they hold. For some people, their priorities are their family, for others, love, money, or other material possessions; nevertheless, if a person does not place a high value on acquiring wealth, then their financial situation will not have an impact on their level of happiness with life in general. Additionally, research shows that those who place a high importance on customs and religion also possess a high degree of life satisfaction.

Religion and life satisfaction

There are two main categories of individuals in the world: those who believe in religion and those who do not. Long-term research has also demonstrated that religious individuals are happier with their life than non-religious ones. Many religious people attend religious services on a weekly, daily, or irregular basis and claim to be "extremely satisfied" with their life. The American Sociological Review claims that those who practice religion experience higher levels of life pleasure because their participation in religious services fosters social networking, which in turn provides them with an additional source of life satisfaction.

Family and life satisfaction

There has been a current trend in life satisfaction when family is included. Because every person's family is unique and influences them in some way, family satisfaction is a relevant topic. Most people aim to be highly satisfied both outside and within their own families. Gary L. Bower claims that the capacity of family members to collectively identify their shared family-related values in behavior improves family life satisfaction.

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Plant Pseudogenes: Decoding the Hidden Regulators in Genome Evolution

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Abstract

The genome, dominated by non-coding regions, was historically deemed as non-functional or junk DNA, encompassing transposable elements, regulatory elements, simple and tandem repeats, functional non-coding RNAs, and pseudogenes. Pseudogenes, discovered in Xenopus laevis as compromised copies of functional genes, are genes that have lost the ability to produce functional proteins due to critical defects in their sequences. Initially considered genomic fossils, pseudogenes are now acknowledged as ubiquitous and abundant in genomes, evolving neutrally. Despite their non-functional protein-coding status, pseudogenes play essential roles in gene regulation, transcribing into RNA, forming small interfering RNA, or influencing cellular miRNA concentration. Bioinformatics tools like Pseudo Pipe and PSF aid in pseudogene prediction. Systematic plant pseudogene studies uncover their lineage-specific expression patterns, demonstrating their crucial role in genome evolution and the potential contribution of pseudogenes to regulatory noncoding RNAs and transcription factor binding sites in plants.

Introduction

In genome, non-coding regions are more abundant than the coding region. These non-coding regions in general were thought to be nonfunctional or junk or no purpose DNA. The non coding regions are transposable elements, regulatory elements, simple and tandem repeats, functional noncoding RNAs, pseudogenes etc. In 1977, Jacq *et al*. discovered in *Xenopus laevis* a truncated copy of a 5S rRNA gene with a compromised function, which they termed a "pseudogene".

Pseudogenes are defined as the gene that have lost its ability to produce functional proteins, which contain critical defects in their sequences, such as lacking a promoter, having a premature stop codon or frameshift mutations. Pseudogenes are ubiquitous and abundant in genomes. They have highest homology to parental functional gene. Most arise as superfluous copies of functional genes, either directly by DNA duplication (unprocessed pseudogenes) or indirectly by reverse transcription of an mRNA transcript (processed pseudogenes). Pseudogenes were once called "genomic fossils" and treated as "junk DNA" several years. They are expected to be evolving neutrally (Xiao *et al.*, 2016).

Nevertheless, it has been recognized that some pseudogenes play essential roles in gene regulation of their parent genes, and many pseudogenes are transcribed into RNA. Pseudogene transcripts may also form small interfering RNA or decrease cellular miRNA concentration. Pseudogenes are usually identified when genome sequence analysis finds gene-like sequences that lack regulatory sequences needed for transcription or translation, or whose coding sequences are obviously defective due to frameshifts or premature stop codons.

Types and Origin of Pseudogenes

Pseudogenes are classified based on functionality, birth, and death of gene families. Zheng and Gerstein's classification includes living genes (functional genes), dead pseudogenes (non-transcribed and evolving neutrally), and ghost pseudogenes (with intermediate functionality). Another classification based on origin distinguishes unprocessed pseudogenes (formed by duplication and mutation), processed pseudogenes (formed by retrotransposition), and unitary pseudogenes (rare, resembling unprocessed pseudogenes). Pseudogenes can originate through duplication events or by accumulating mutations in the parental DNA sequence. Duplicated pseudogenes arise when a duplicated copy of a functional gene acquires deleterious mutations, resulting in the loss of its original protein-coding capacity. Unitary pseudogenes form through the accumulation of mutations in a single gene without prior duplication.

Pseudogenes in Plants

While pseudogenes are predominantly studied in mammals, their presence in plants is gaining attention. Pseudogenes have been identified and predicted in various plant species, including Rice, Arabidopsis, Rye, Barley, Soybean, *Medicago truncatula, Populus trichocarpa*, Sorghum, and *Brachypodium distachyon*. Mascagni *et al*. (2021) identified and characterized the pseudogene complements of five plant species: *Arabidopsis thaliana*, *Vitis vinifera*, *Populus trichocarpa* and *Phaseolus vulgaris*) and *Oryza sativa* based on sequence homology to functional loci.

Prediction of Pseudogenes

Bioinformatics approaches play a crucial role in pseudogene prediction due to the high sequence similarity between functional genes and pseudogenes. Bioinformatics tools for pseudogene prediction have been developed, among which Pseudo Pipe, PSF (Pseudogene Finder), Shiu's pipeline are publicly available (Xie *et al.*,2019). Some other tools such as PPFinder, and Plant pseudogene use homology-based approaches to identify pseudogenes based on parent-pseudogene homologous pairs.

Utilities of Pseudogene

Pseudogenes play crucial roles in gene expression and regulation, contribute to solving biochemical pathways, provide information on splice diversity of RNA, and exhibit a neutral substitution rate. Garewal *et al. (*2022) functionally characterizes diverse roles of the resistance pseudogenes as novel gene footprints and as significant gene regulators in the grapevine genome. They used PlantPseudo pipeline and HMM-profiling to identify whole-genome duplication-derived (WGD)pseudogenes associated with resistance genes (ψ-Rs).

Ali *et al*. (2013) conducted studies in formation and expression of pseudogenes on the B chromosome of rye and results revealed that Bs of rye (*Secale cereale*) are rich in gene-derived sequences. They compared these gene-like fragments of the rye B with their ancestral A-located counterparts and confirmed an A chromosomal origin and the pseudogenization of B-located gene-like fragments. About 15% of the pseudogene-like fragments on Bs are transcribed in a tissue-type and genotype-specific manner. In addition, B-located sequences can cause in trans down or upregulation of A chromosome encoded genic fragments. Phenotypes and effects associated with the presence of Bs might be explained by the activity of B-located pseudogenes. We propose a model for the evolution of B-located pseudogenes.

Xie *et al.* (2019) conducted few systematic studies of plant pseudogenes, hampering comparative analyses. They examined the origin, evolution, and expression patterns of pseudogenes and their relationships with noncoding sequences in seven angiosperm plants. They identified 250,000 pseudogens, most of which are more lineage specific than protein-coding genes, showing tissue or stage specific expression patterns and also found that a large fraction of nontransposable element regulatory noncoding RNAs (miRNAs and lnc RNAs) originate from transcription of pseudogenes proximal upstream regions. They also found that transcription factor binding sites preferentially occur in putative pseudogene proximal upstream regions compared with random intergenic regions, suggesting that pseudogenes have conditioned genome evolution by providing transcription factor binding sites that serve as promoters and enhancers.

Resistance genes associated pseudogenes (pseudo-R genes) derived from whole-genome duplications were identified in the genome of Vitis vinifera and were annotated for their roles in plant defense responses. Pseudo-R genes play by regulating the gene expression either directly by acting as mRNA mimics for miRNA/tasiRNA targeting or indirectly by lncRNA mediated regulation of miRNA/tasiRNAs (Garewal *et al.,* 2022)

Future Aspects

Understanding the mechanisms of pseudogene action may unlock solutions to essential biochemical pathways. Pseudogenes, often considered junk DNA, are emerging as critical players in gene regulation.

Reasons to Take Pseudogenes Seriously in Research

Dysregulation of pseudogenes may contribute to the pathogenesis of various diseases. Pseudogenes can affect functional gene expression, and failure to distinguish their transcription level from functional genes may impact research data accuracy.

Conclusion

Pseudogenes, once labeled as junk DNA, are gaining prominence in genomic research. Their evolutionary significance, functional roles, and potential contributions to disease pathogenesis highlight the need to study them seriously. Pseudogenes, often overlooked, might hold the key to unraveling intricate aspects of genome regulation and evolution. As research progresses, pseudogenes are likely to become central players in understanding the complexity of genomic landscapes

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Role of Women in Agriculture

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Women contribute significantly to the agricultural and rural economies of all developing countries. Their roles differ significantly between and within regions, and they are rapidly changing in many parts of the world where economic and social forces are transforming the agricultural sector. Rural women frequently manage complex households and pursue multiple sources of income. Rural women everywhere play an important role in achieving food and nutrition security, generating income, and improving rural livelihoods and overall well-being. They benefit agriculture and rural businesses, as well as local and global economies. In India, 85% of rural women work in agriculture, but only about 13% own land. Women contribute to agriculture in a variety of ways, including cultivators, entrepreneurs, and laborers. Women's participation in agricultural practices improved organic fertilizer and bio-pesticide adoption, but it had no effect on agroforestry adoption. This confirms that women are more likely than men to be concerned about agricultural sustainability.

Weeding, hoeing, grass cutting, picking, cotton stick collection, separation of seeds from fiber, livestock keeping and its associated activities such as milking, milk processing, ghee preparation, and so on are all performed by rural women. Women in agriculture are frequently subjected to gender-based violence, such as sexual harassment, assault, and exploitation. Gender-based violence in agricultural settings must be addressed in order to protect women's human rights, promote their safety and well-being, and allow them to fully participate in agricultural development.

Problems faced by women farmers in India

In every sector woman face many problems. In agriculture too they face many problems like they are not equally treated like men in the wage distribution and allotment of work. Sometimes they have work load, but due to the availability of the machinery they do not get their employment. Women almost never have access to land, financing, markets, agricultural training and education, safe working conditions, or equal treatment. All of these issues place the majority of female farmers at a significant disadvantage. 'Even after 75 years, the situation of women farmers remains precarious. Farmers' poverty and illiteracy prevent them from making large-scale capital investments and adopting scientific farming methods. Small land holdings as a result of rapid population growth, which causes land fragmentation in rapid succession.

Why women should be empowered in agriculture?

If women had equal access to productive resources as men, they could significantly increase farm yields, reducing the number of hungry people around the world. The empowerment of women ensures that they have an equal voice in decisions that affect their communities and way of life. Women's self-esteem grows, and they make strides toward contributing to the nation's growth. Women's social status is rising, and they are better recognized and appreciated. They can make their own financial decisions and become financially independent. Equal opportunities for women in India would enable them to contribute to the economy as productive citizens.

Women can thrive economically and rise out of poverty with higher literacy rates and equal pay for equal work. Gender equality is critical to achieving food security, nutrition, and all of the Sustainable Development Goals. 2. Many developing countries' agriculture sectors are underperforming, and one reason is that women do not have equal access to the resources and opportunities they require to be more productive.

Conclusion

Agriculture has contributed significantly to society. However, it has its own set of advantages and disadvantages that we must consider. Furthermore, the government is doing everything possible to aid in the growth and development of agriculture; however, something needs to be done to address agriculture's negative impacts. Women are the backbone of the agricultural workforce, but their efforts are mostly unrewarded around the world. She performs the most laborious and back-breaking tasks in agriculture, animal husbandry, and households. A growing number of women are receiving a good education. However, true women's empowerment will be realized when gender inequality is eliminated. We must provide equal opportunities for equal pay and equal respect for women as we do for men.

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Transgenic Cowpea: Promising Solution for Cowpea Cultivation Challenges in Agriculture

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Abstract

Conventional breeding faces hurdles due to the apparent lack of resistant genes and cross-incompatibility with wild vigna species. Genetic engineering, specifically transgenic approaches using Agrobacterium tumefaciens, emerges as a promising solution. Successful attempts, spanning four decades, have demonstrated the feasibility of generating transgenic cowpea, with recent studies showcasing the utilization of the insecticidal protein Vip3Ba1 from Bacillus thuringiensis to confer pest resistance. This concludes that transgenic cowpea lines, such as TCL-709 and TCL-711, can be served as the potential and valuable sources of resistance against the maruca pod borer, offering hope for the development of maruca-resistant cowpea varieties to benefit African farmers under natural field conditions.

Introduction

Cowpea is a annual, herbecious, drought tolerant, grain legume. It is used for its grain, tender pod and it is also used as fodder for animals. Because of its great economic importance, cowpea has been the target of breeding programs for many years in different centers of research the world over. The ultimate goal of these programs is to address agronomic problems such as attack by virus, bacteria, pests and diseases. Unfortunately, the apparent unavailability of resistant genes in the plant has rendered the conventional breeding approach less attractive in strategies for producing pest-resistant genotypes of cowpea. This task is even more herculean given the cross-incompatibility between the cultivated and wild vigna species that may possess some inherent resistance. Genetic engineering offers important strategies with promising results in addressing not only problems caused by pests and diseases, but also by viruses.

In the last four decades, a number of attempts have been made to generate transgenic cowpea. The general approach in most cases has been through the employment of *Agrobacterium tumefaciens* as a gene delivery system via tissue culture.The first of such reports appeared in 1986, when Garcia transformed leaf discs from primary leaves of cowpea using *A. tumefaciens* designed with Ti plasmid harboring two identical chimeric genes for kanamycin resistance, it took close to a decade to produce the first transgenic cowpea plants when Muthukumar (1996) co-cultured explants of cotyledons with disarmed *A. tumefaciens* expressing the gene for resistance against hygromicin.

Bett *et al.* (2019) utilized Agrobacterium-mediated gene delivery to explants derived from the cotyledonary nodes of imbibed cowpea seed. The explants were regenerated following a sonication procedure and a stringent selection comprising alternating regimes of kanamycin and geneticin. The method was reproducible and led to the recovery of independent fertile transgenic plants in the greenhouse at a level of about one per cent of starting explants. A transgene encoding an insecticidal protein from *Bacillus thuringiensis* was used to demonstrate the efficacy of the system.

Bett *et al*. (2017) collected of 224 Bt isolates which were screened with gene-specific primers to identify those containing target vip genes namely vip3Aa35, vip3Af1, vip3Ag, vip3Ca2 and vip3Ba1. The coding sequences of the vip3 genes were cloned and over-expressed in *Escherichia coli* to produce Vip3 protein. The proteins were incorporated into Maruca artificial diets for use in insect bioassays with MPB larvae to screen for toxicity, of these, Vip3Ba1 protein was found to strongly inhibit larval growth and was selected as the candidate gene for cowpea transformation.

Cruz *et al.* (2014) produced ten cowpea transgenic lines presenting a normal phenotype and transferring the transgene to the next generation. Plants were tested for resistance to both Cowpea severe mosaic virus (CPSMV) and Cowpea aphid-borne mosaic virus (CABMV) by mechanical co-inoculation. Seven lines presented milder symptoms when compared to the control and three lines presented enhanced resistance to both viruses. Northern analyses were carried out to detect the transgene-derived small interfering RNA (siRNA) in leaves and revealed no correlation between siRNA levels and virus resistance. Additionally, in the symptomless resistant lines the resistance was homozygosis-dependent. Only homozygous plants remained uninfected while hemizygous plants presented milder symptoms.

Mohammed *et al*. (2014) crossed two transgenic events TCL-709 and TCL-711 were crossed to three non-transgenic lines IT97K-499-35, IT93K-693-2 and IT86D-1010 to generate six set of F_1 hybrids. The study was designed and conducted to evaluate the performance of transgenic cowpeas and hybrids derived from them under natural field conditions and concluded that transgenic cowpea lines can be use as precious source of resistance to maruca pod borer in the development of maruca resistant cowpea varieties for the benefit of African farmers.

Kumar *et al.* (2021) developed transgenic cowpea plants expressing *Bacillus thuringiensis* Cry2Aa insecticidal protein using *Agrobacterium tumefaciens*-mediated transformation of cotyledonary explants. T_0 plants recovered from *Agrobacterium* cocultured explants on medium containing 120 mgl^{-1} of kanamycin were identified on the basis of the presence of transgenes by PCR, their integration into genome by Southern hybridization and expression of their transcripts by semi quantitative PCR (sqRT-PCR) and quantitative Real–time-PCR (qRT-PCR) and protein by Western blot analysis. The transformation efficiency obtained was 3.47% with 11 independent T_0 transgenic lines. The bio efficacy of Cry2Aa protein expressed in randomly selected four T_0 plant's leaves and pods was evaluated by feeding Maruca pod borer demonstrated a significant lower damage and a high level of Maruca mortality (more than 90%) for all these *Bt* lines. The inheritance of transgenes from T_0 to T_1 progeny plants was demonstrated by PCR analysis. The transgenic plants generated in this study can be used in cowpea breeding program for durable and sustainable legume pod borer resistance.

Current status and Future Prospects

Currently, various research groups in countries possess well established transformation systems which can be harnessed to improving cowpea. The recalcitrant nature of cowpea for in vitro regeneration has been tackled and cowpea carrying a gene of cry1ab has been commertialized. Recently in Nigeria (2019) the world's first genetically modified (GM) cowpea named Sampea 20-T was registered and approved for release to smallholder farmers in Nigeria. The new variety carries a microbial insecticidal gene making it resistant to a major pest that affects this crop.

The demand for genetically improved cowpea is increasing because of its immeasurable value for food, feed and soil improvement. However, new techniques are needed in pest management systems, due to continuous development of resistance against the existing control techniques. With the emergence of promising new tools like the CRISPR/Cas9 system, it is expected that the speed with which new and desirable traits are effectively inserted into cowpea genome has improved.

Conclusion

Currently, various research groups in countries including Australia, Brazil, India and Nigeria possess well established transformation systems which can be harnessed to improving cowpea, a hitherto unreachable goal by means of traditional breeding. Challenges posed by pests and disease can be tackled through systematic application and optimization of the protocols arising from the efforts of the last three decades. In the last few years, significant progress has been made to establish different protocols and their application in the development of transgenic cowpea with one type of characteristic or another. (Citadin *et al*., 2011)

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Sholas of Nilgiris: Lifeline of Cauvery Delta Farmers

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The Shola forests present in the Western Ghats derive their name from the Tamil word *solai*, which means a 'tropical rain forest' and classified as 'Southern Montane Wet Temperate Forest (11 A/c1)' according to Champion and Seth. These Shola forests are found in the upper hills of the Nilgiris, Anamalais, Palni hills, Kalakadu, Mundanthurai and Kanyakumari in the states of Tamil Nadu, Karnataka and Kerala. These forests are found sheltered in the valleys with sufficient moisture and proper drainage at an altitude of more than 1,500 metres elevation. The upper reaches of the Shaola forests are covered with grasslands known as Shola grasslands. While 70% of the Nilgiris were native grasslands, 30% of land was shola forests. The forests are also known as 'cloud' forests, holding the ability to draw moisture from the mist and retain cloud cover. The shola biome has a high water retention capacity and exists as the primary source of the water for the high elevation organisms is the origin of many streams and rivers including Cauvery in the Western Ghats.

The vegetation that grows in Shola forests is evergreen. The trees that grow in these forests are stunted in nature and have many branches with rounded and dense canopies in the shape of Caluliflower. In General, the leaves are small in size and leathery. The Red-coloured young leaves turning into different colours on maturity is a prominent characteristic of the Shola forests with mosaic appearance. Epiphytes like lichens, ferns and bryophytes are usually grown on the trees.

The occurrence of Himalayan plants like Rhododendron is a mystery and characteristic feature of these Shola forests. According to paleobotanist Vishnu Mitter, these are remnants of the vegetation driven to South India during the Quaternary Ice Age, about 2.6 million years ago, with subsequent changes in the tropics of South India. Shola forests play a major role in conserving water supply of the Nilgiris' streams. In his book *The Nilgiris* (1908), W Francis says, "The Sholas of the plateau are not of any great

Longwood Shola

Kotagiri

Nilgiri Marten

Nilgiri tahr

importance from a commercial point of view, as the trees are slow-growing varieties which produce timber of little or no value and probably take at least a century to mature. But they add greatly to the beauty of the country and are of immense use in protecting source of water supply." Sholas thus act as overhead water tanks.

The rolling grasslands found on top of the Western Ghats, enhance the beauty of the region. Usually, Shola forests and grasslands are found in a ratio of 1:5. Pastoral communities, who settled in the grasslands centuries ago, burn the grasses periodically. This has checked the advance of the Shola forests. As tree species of the montane, evergreen forests are flammable, regeneration of any Shola tree species is completely prevented except for *Rhododendron nilagiricum*, the only Shola tree that can tolerate fire.

The rain received from the Southwest and Northeast monsoons is harvested by the Shola forest-grassland ecosystem, leading to the formation of the Bhavani River that finally drains into the Cauvery. Thus, the Shola forest-grassland ecosystem of the

Nilgiris, also supports the prosperity of Cauvery delta farmers.

Problems for Shola Forests

Due to the introduction of alien plant species and annual fire occurrences, the area under Shola forests has begun to gradually shrink.

- Alien species like Sticky Snakeroot, Gorse and Scotch Broom introduced during the British rule, have encroached upon the Shola forests as well as grasslands.
- During 1840, the tree species such as *Acacia mearnsii* and Eucalyptus were introduced from Australia mainly to meet the Tannin and Pulp requirements respectively.
- Between 1886 and 1891, Pine and Cypress were introduced, again from Australia. As the alien species grew, the Shola forests and grasslands gradually became degraded and shrank.
- In addition, unscientific agricultural practices like growing tea on the slopes, cattle grazing and fuel wood collection have become serious causes for degradation.
- Unregulated tourism has created concrete jungles, traffic congestion and caused the generation of garbage.

Land use studies undertaken on the Nilgiri Biosphere Reserve between 1849 and 1992 show the extent of the damage. During 1849, the extent of Shola forests was 8,600 ha, grasslands 29,875 ha and agriculture was 10,875 ha. No wattle or eucalyptus was planted in the area at that time. During 1992, it was found that the extent of Sholas was 4,225 ha, grasslands 4,700 ha, agriculture 12,400 ha, tea plantations 11,475 ha, wattle plantations 9,775 ha and eucalyptus plantations was 5,150 ha. The comparison of the results of the 1849 and 1992 studies shows that cultivation of tea, wattle and eucalyptus has reduced the Shola forest-grassland ecosystem to a greater extent.

Conservation Measures taken

The government banned the planting of wattle and eucalyptus completely in 1987 as it causes serious damage to Shola-Grassland ecosystem. Ecological restoration and biodiversity conservation were given much importance. Under the Hill Area Development Programme since the mid-1980s, seedlings have been planted in degraded patches and protected with chain-link fences to restore the forests.

Special Shola Forest protection committees were formed involving teachers, nature lovers, ecologists, environmentalists, students and villagers in the Nilgiris. They were motivated to remove plastic garbage from the nearby forests, protect Shola trees, remove alien species and learn about the importance of the Sholas. The forest department started supplying LPG cylinders to the nearby villagers of the Shola forests as they depended upon the forests for their fuel wood needs. This helped the forests a great deal as the entry of people in them was stopped.

Presently, the Tamil Nadu Forest Department focuses on eradicating all exotics including wattle, providing fencing and planting shola seedlings in degraded shola forests. The Shola-grassland ecosystem, which acts as the Nilgiris overhead water tank and the water source for the farmers of Cauvery Delta, can only be saved with the involvement and cooperation of all stakeholders' *viz.*, the common public, students and nature enthusiasts with the government. If the forests and grasslands are restored, the region's water problems will be solved to a great extent.

Finally, to conclude we all should take a pledge to conserve the Shola Forests of Nilgiris which act as a source of water for the perennial rivers like Bhavani and Cauvery for the better future of the farmers of Cauvery delta region.

"SAVE SHOLAS TO SAVE RIVERS"

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Solar Drying Technologies for Agricultural Produce– An Overview

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Conversion and utilization of solar energy is one of the most important strategies being proposed to mitigate the foreshadowed global energy crisis and environmental issues. Agricultural produce is the backbone of food security and economic stability for many regions around the world. However, a significant portion of this produce is lost due to inadequate post-harvest handling and preservation techniques. Solar dryer has a significant potential in the agricultural sector, where it used for drying vegetables, fruits and medicinal plants. Solar energy translates to heat during the drying process, so whether product is laid out in the sun (ambient) or placed in a dryer, the heat for drying comes from the same source. In traditional drying methods, agricultural produce is exposed to direct sunlight or air-dried in open fields, which is not only time-consuming but also susceptible to contamination, pests, and unpredictable weather conditions. Solar drying provides an efficient and controlled environment for dehydration, ensuring that the produce retains its quality and nutritional value. In this article, we will explore various solar drying technologies and their applications in agricultural sector. In recent years, with the rapid development of drying technology and the application of drying equipment, drying industry is making great development.

Solar Energy

Depletion of natural fuel resources, rising fossil fuel costs and emission have led to use renewable energies. Various innovations are undergoing to make the use of sources of renewable energy like wind, solar, tidal etc. Among these sources, solar energy is available in enormous quantity and can be directly used which is continuous, safe, free and environment friendly. Increasing population is the major problem of the entire world. Increase in the population increases the consumption of food. To fulfil this demand either that amount of food must be produced on a regular basis or produced food can be stored after some processing. Therefore, continuous production is not possible but food can be stored for a certain period by drying it. For drying agricultural and non-agricultural products, solar energy can be used directly or indirectly (Singh *et al.*, 2018).

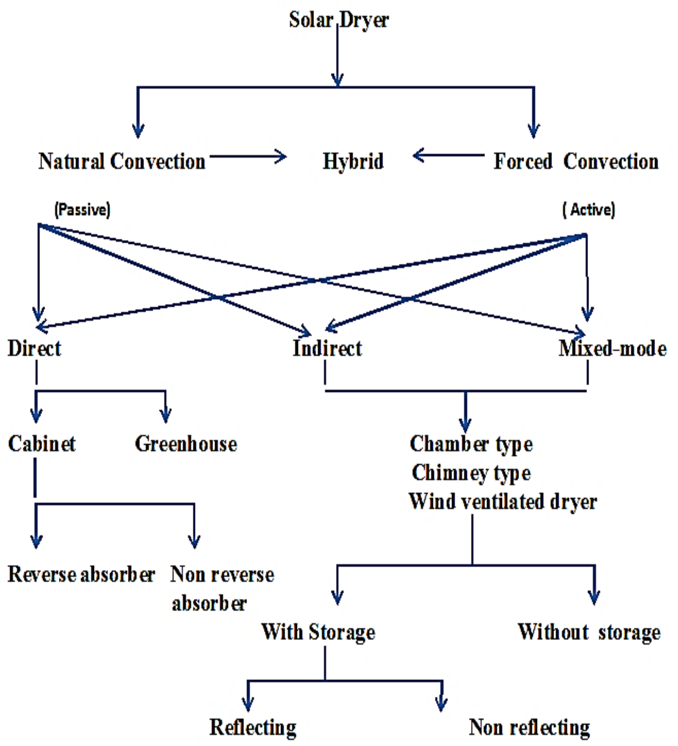
Solar dryer

Solar dryer has a significant potential in the agricultural sector, where it used for drying vegetables, fruits and medicinal plants. Thereby minimize dependency on sun drying and industrial drying, hence save huge quantities of fossil fuels (Agrawal and Sarviya, 2016). Drying involves extraction of moisture from the product by heat and removal of that moisture by a flowing air mass. Solar dryer is the best alternative option to avoid disadvantages of conventional drying methods (Sontakke, and Salve, 2015). Traditionally all the agricultural products were dried only by utilizing solar energy which requires large area for drying and availability of the sunlight throughout the day. The chances for contamination of the drying product with dust, insects, birds, fungi etc. are more in the open sun drying.

The above said challenges have led to the development of solar drying systems. Many solar driers have been developed in the past two decades for drying various products by utilizing the solar energy efficiently and innumerable studies has been reported on solar drying of agricultural products (Leon *et al.*, 2002). Agricultural products, especially fruits and vegetables require hot air in the temperature range of 45–60˚C for safe drying. When any agricultural product is drying under controlled condition at specific humidity as well as temperature it gives rapid superior quality of dry product (Gutti *et al.*, 2012; Sontakke, and Salve, 2015). Solar drying is one of the best methods to preserve crops for a long time. Greenhouse solar dryer operating in active mode is better as compared to passive mode. Quality, taste, colour, and nutritious value of the dried product are better in greenhouse solar drying than open sun drying

Types of solar dryers

Solar dryers are mainly classified into natural convection dryers, forced convection dryers and hybrid type. In natural convection or active solar dryer, the circulation of solar heated air is through buoyant force. A forced convection or passive solar dryer utilizes motorized fans or pumps for forced circulation of the drying air in to the solar dryer in which solar energy is used to heat the pumped air. In a Hybrid dryer solar energy is combined with conventional or auxiliary source of energy for heating the air. Classification of solar dryers (Fudholi *et al.*, 2010).



Conclusion

To capture and efficiently utilize the solar energy in today's energy market requires multistage integration of several factors, including proper matching of the solar energy resources and energy demands of a particular region. Use of solar energy for drying is one of the most effective methods due its renewable nature and availability. Solar drying technologies represent a significant advancement in agricultural post-harvest handling and preservation. By harnessing the sun's energy, farmers can reduce post-harvest losses, improve the quality of their produce, and contribute to a more sustainable food system. In recent years, with the rapid development of drying technology and the application of drying equipment, drying industry is making great development. With proper training and support, solar drying has the potential to revolutionize the way we approach food preservation, benefiting both farmers and consumers alike.

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Applications of Artificial Intelligence in Aquaculture

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Currently, Aquaculture plays a critical role in meeting the budding global demand for Aquaculture and fisheries products; however, it faces immense challenges in fish growth, seed production, feed utilization, health status and remote monitoring. With technological advancements, the artificial intelligence (AI) technique offers inspiring resolutions for enhancing fish farming practices and certifying sustainable aquaculture development. With this new sophisticated and dynamic artificial intelligence (AI) technique, we aim to convert aquaculture from art into more of a science. The utilization of modern AI technology significantly frees up human resources, upsurge current manufacturing efficiency, and aids in increasing output, product quality, and other conveniences. There are numerous applications of AI systems in aquaculture, and the important ones are listed:

Remote automated monitoring

With AI in aquaculture, the aquaculturist can remotely monitor and maintain the farming site. AI systems control cloud infrastructures to give remote site-level examination and glitch detection to levels never grasped before. AI systems will give alarming signals to farmers about water levels, any blockages, low oxygen levels or any other concern that might be important to resolve instantly. It helps the farmers to roam freely by remote monitoring and maintenance while being capable of monitoring their aquaculture sites with accuracy. The necessity to continuously remain present in the field is no longer possible due to AI only (Yongqiang *et al.*, 2019).

Ai-based automated feeding

As feeding represents the biggest cost to farmers, which involves more than 50% of input cost, optimization in this area always means better profitability. The use of AI-based Automated Feeding systems has revolutionized the feeding process in fish as the farmers have to fed fish manually, and feeding is a tiresome process. Remaining constantly available, farmers can occasionally forget, or they may even remain inaccessible for certain purposes. This is where AI can be extremely important and step into the fish farmer's shoes using automated feeding systems. This AI-based Automated Feeding system has AI-empowered tools that release a registered amount of feed at a particular time for fish to intake, minimize feed wastage and improve feed consumption among the fishes. The proximate composition of feed, its nutrient profile and energy content will be displayed all the time to improve the nutritional content and shelf life of fresh and processed fish products. It can also help fish products retain their natural flavours and aromas.

Examine growth and biomass

The calculation of manual biomass in aquaculture gives significant challenges as it's time-consuming and tedious with no considerable enhancements. The correctness of these dimensions relies heavily on the worker's skills and knowledge, making them vulnerable to human error. Furthermore, physical measurements are characteristically restricted to small samples, which may provide an inaccurate representation of the entire fish population in ponds. This restriction results in errors when approximating the total biomass. In addition, frequent labour-intensive measurements cause stress, disrupt their feeding patterns and condition their health. By utilizing the power of AI, farmers not only identify the dodges in their cultivation practice but are aware of the upcoming steps and loss control to ensure that their fish stock turns out to be fruitful. It will contribute to the collection of big data and analytics to help others analyse the correct practices and steps for the same. Meanwhile, combining machine vision and machine learning can better assess fish size, weight, numbers, and other biological data (Zhao *et al.*, 2021).

Water quality management

Another important advantage of using AI in aquaculture is that it can easily detect water quality and regulate it. As we know, water quality is the main and important factor that determines the growth, health and survivability of fishes throughout the process of culture. Any contamination with water tends to infect the pond/water body. AI-empowered sensors can simply inform the farmer and lead to supervisory measures. This particular application of AI makes the aquaculture industry very advanced yet progressive.

Regulating temperature

Temperature is one of the critical factors regulating the growth and development of fishes, and its regulation is important for the growth and experimental analysis of fishes. Temperature optimization can be done through artificial intelligence and machine learning algorithms that allow farmers to customary their preferences and extract modified models for their fish culture site. For example, AI can help farmers to increase it at night.

Human-less filtration

In earlier times the filtration of aquaculture farmers manually to maintain the water quality, the contemporary era has become much more advanced. As Motorized by AI, human-less water filtration can be easily done with the help of pre-installed machinery. Hence, the practice of AI in aquaculture denies the need for farmers to manually perform tiresome activities and spend long hours in the same. At the same time, performing and monitoring all the functions to cope with the demands of culturing practices and lead to better outcomes for the practice altogether.

Data analytics

One of the important applications of AI in aquaculture is that it can utilize big data analytics to collect information records and help others take the right steps. With the benefit of data analytics, farmers can very well recognize the risks and encounters that they might face in the process and take appropriate steps to ensure that they are on the right path. So, data analytics not only provides you with a summary of the practice but also capitulates the dos and don'ts to help farmers.

One of the chief applications of artificial intelligence, predictive analytics paves the way for aquaculture practitioners not only to strategize their upcoming actions but also work along the lines of the forecasted notions so that they can do the best for their cultural practices. Artificial intelligence is improving aquaculture by making farmers understand the analytics of how their inputs affect fish growth under various conditions.

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Shift from Conventional to Organic Agriculture

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Sifting from conventional farming to organic farming is a step-by-step procedure and consist of commonly three steps. In a first step, collecting information on appropriate organic farming practices. In a second step, practices should be tried out on selected plots or fields for validation. In a third step, only organic procedures should be implemented in the entire farm.

Step I: Gather Information First

Successful organic farming requires considerable knowledge on the functioning and the possibilities of management of natural processes. Farmers who are interested in adopting organic farming practices are recommended to get in contact with farmers in the area, who already successfully practice organic farming to learn from them. Some farmers may be good at making compost, some at growing green manures. Learning from experienced farmers allows to get first-hand experience under local conditions, and thus to learn about the advantages and major challenges related to implementing organic methods.

Information may gather from difference sources like: Radio, Internet, videos from Youtubes, Book and booklets Training, Group discussion etc.

Basically, farmers who are interested in converting their farm to organic farm need to know:

- How to improve soil fertility.
- How to keep crops healthy.
- How to best increase diversity in the farm.
- How to keep livestock healthy.
- How to give value to organic products and how to successfully sell them.

Step 2: Getting Familiar with organic practices

Data collected for information about the requirements, the potentials and the main practices related to conversion, farmers should start to learn from their own experience on their own farms. To minimize risks of crop failure and losses of animals, and avoid frustrating overload, farmers are recommended to implement organic practices step-by-step to a limited extent, selecting specific practices at a time and testing them on selected plots. But which practices should one choose to start with? As would seem natural, farmers should start by applying practices that are of low risk and investment, require little specific knowledge, limited additional labour, and with high short-term impact. The practices may like to:

- **Mulching -** Covering the soil with dead plant material is an easy way to control weeds and¬ protect the soil in annual crops. This practice can be implemented into most existing cropping systems. The main question may be, however, where to get appropriate plant material from.
- **Intercropping** - Growing two annual crops together, commonly a leguminous crop like beans¬ or a green manure crop in alternating rows with maize or another cereal crop or vegetable is a common practice in organic farming to diversify production and maximize benefits from the land. In intercropping, special attention must be paid to avoid competition between the crops for light, nutrients and water. This requires knowledge on arrangements, which promote growth of at least one of the crops.
- **Composting** - Application of compost to the fields can have a major impact on crop growth and¬ yields. To start compost production, farmers will need enough plant materials and animal manures, if such are available. In case such materials are scarce, farmers would first have to start producing plant materials on the farm by sowing fast growing leguminous

plants that build a lot of biomass, and by introducing some livestock on the farm for manure production, if this proves appropriate. To get familiar with the process of making compost, farmers should be instructed by an experienced person. Proper compost production requires some knowledge and experience and additional labor, but is low in investments.

- **Green manuring -** The practice of growing a leguminous plant species for biomass production and incorporation into the soil may be new to most farmers. Nevertheless, this practice can greatly contribute to improvement of soil fertility. Green manures can be grown as improved fallows, as seasonal green manures in rotation with other crops, or in strips between crops. Proper green manuring first requires information on appropriate species.
- **Organic pest management** – Careful associations and management of plants and animals in¬ order to prevent pest and disease outbreaks. Initially, bio-control agents may be applied but organic pest management is best achieved through ecological approaches that establish a pest/predator balance. While the choice of resistant varieties of crops is paramount, other prevention methods include: choosing sowing times that prevent pest outbreaks; improving soil health to resist soil pathogens; rotating crops; encouraging natural biological agents for control of disease, insects and weeds; using physical barriers for protection from insects, birds and animals; modifying habitat to encourage pollinators and natural enemies; and trapping pests in pheromone attractants.
- **Appropriate seeds and planting material** - Use of healthy seeds and planting materials, and¬ robust and/or improved cultivars can make a big change in crop production. This practice may require some information on selection of seeds and planting materials including availability of improved varieties and seed treatments. Generally, locally-adapted seeds are preferred because of their resilience to local conditions.
- **Planting of leguminous trees** - In perennial crop plantations such as banana, coffee or cocoa, planting of leguminous trees such as gliricidia, calliandra, and sesbania may improve the growing conditions of the fruit crop by providing shade, mulching material and nitrogen through nitrogen fixation. In addition, some leguminous trees provide good fodder for livestock. This practice requires some knowledge on shade and space requirements of the tree crops and thus on ideal planting patterns for the leguminous trees.
- **Growing farm-own animal feeds** - To improve available feeds for the livestock, farmers may¬ grow grasses and leguminous fodder crops around, between other crops or in rotation. As animal feed must be of organic origin, feed sources are best addressed by considering farm grown feed**.**
- **Terraces and soil bunds -** Construction of terraces and soil bunds along the curves of hills is a key measure for soil conservation. This practice builds the foundation of further improvement to soil fertility on slopes. It is of high relevance, but requires much labor and some specific knowledge for appropriate implementation.

Selection of Crop to Grow During Shift

Crops that can easily be integrated into the prevailing cropping system and will depends on the farmer's knowledge on the right management of the crops. It also fit for family diet or their demand in the market. Farmers must convince about growing crops cereals, leguminous or oilseeds, Planting trees for shade, as windbreak, for firewood, feed, mulching material or for other uses, can be recommended in most situations.

Criteria for crop selection during Shift

a) Selection should be based on farmers requirement like food for their family or want to grow crops for the market to get money or grow crops that contribute to improvement of soil fertility or for livestock need to grow pasture grass and legumes.

b) Cereals (Paddy, Wheat, maize, sorghum, millet) and legumes (beans and peas) are especially suitable for conversion, since they cost little to produce and have moderate nutrient demands and are tolerant against pests and diseases. High-value short term crops like vegetables, are more delicate to grow and highly susceptible to pest and disease.

c) Choosing the right crop to sell on the market may require some market information. Decision making for crops for local or export markets requires detailed information from traders or exporters on the crops, requested varieties, quantities, qualities, regularity and season.

d) High-value perennial crops such as fruit trees take at least 3 years until the first harvest from the date of planting. This makes them appropriate crops for the conversion period.

e) The success of a crop will also depend on provision of favorable growing conditions. The better a crop variety matches local soil and climate conditions, and is tolerant or resistant to common pests and diseases, the better it will grow.

f) Growing leguminous green manures provides nutrients to the soil and in the long-term, they make the soil fertile and productive for the future crops.

Step 3: Full Conversion to Organic farming

After gaining sufficient experience with different practices of organic farming it should be implemented throughout the entire farm, and called as an organic farmer. Consistent application of organic practices marks the beginning of a long process of improving the production system:

1. Improving soil fertility based on the recycling of farm own organic materials and enhancement of farm own biomass production.

2. Encouraging positive interactions between all parts of the production system (the farm ecosystem) to enhance self-regulation of pests and diseases.

3. Optimizing the balance between feed production and livestock.

Mitigating Contamination Risk

a) **Pesticides**: Organic farmers are responsible to protect the organic fields from being sprayed with synthetic pesticides. To avoid pesticide drift from neighbouring fields onto the crops, organic farmers should safeguard the organic fields by using any of the following measures:

- Planting of natural hedges on the boundary to neighbouring fields can avoid the risk of pesticide spray drift through wind or run-off water. The wider the border area around the fields, the better.
- To avoid runoff from upstream fields, organic farmers should divert the water away or talk to the farmers upstream about how to work together to minimize the risk of contamination through water.
- Organic farmers, who are interested in saving nature, should share their knowledge and experiences with neighbours with the aim of helping them to either adopt organic farming practices or to minimize the risk of contaminating nature.

b) **Genetically Modified Organisms (GMO)**

- Genetically modified products should, therefore, not be used in organic farming, and organic farmers should protect their production against any GMO contamination.

- Besides the genetic contamination, there is also a risk of physical contamination caused by GMO residues along the production and market chain, if GMO and organic products are not properly separated during storage and transportation.

Recommendations to farmers for reducing the GMO contamination risk:

1. Use organic seed.
2. Put buffer zone.
3. Avoid planting the same crop as your neighbor, if they grow potentially GMO crops
4. Practice a wide crop rotation.

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Reasons and Impact of Agricultural Diversification on Enhancing Farming Income

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Diversifying commercial crops is currently a key strategy for boosting agricultural profitability and lowering the risk of crop failure. Additionally, diversification can help with job planning, environmental preservation, and poverty alleviation. Variety in crop production does not ensure higher yields, but it may help to stabilize them. Utilizing complementary interactions, diversification increases profits. At the national level, agricultural diversification has been emphasized as a method of boosting income and generating employment. With good success, several nations have experimented with crop diversification to boost productivity and grow high-value crops in response to the challenges posed by a globalizing agricultural market as well as the rising and shifting needs of the populace. These nations are gradually broadening their economies. The crop sectors in these nations are gradually being diversified in favor of high-value products, including fruits, vegetables, and spices. The influence of agricultural diversity on farm revenue and the impact of agricultural diversification on employment The diversification between food and non-food crops, traditional crops and horticulture, high-value and low-value crops, etc., is implied by changing a cropping pattern.

Reasons for farmers to consider agricultural diversification

Agricultural diversification is the practice of varying the range of crops, livestock, or agricultural activities on a farm. There are several compelling reasons for farmers to consider agricultural diversification:

1. Risk Reduction: One of the primary reasons for diversification is risk reduction. Relying on a single crop or livestock can make a farm vulnerable to various factors like weather-related disasters, pests, diseases, or market price fluctuations. Diversifying can help spread these risks.

2. Income Stability: Different crops and livestock have varying growing seasons and market cycles. Diversifying allows farmers to have a more stable and consistent income throughout the year. When one product is out of season or has low market prices, income from other diversified activities can help bridge the gap.

3. Soil Health and Sustainability: Crop rotation and diversification can improve soil health by reducing soil degradation, erosion, and nutrient depletion. Certain crops, like legumes, can fix nitrogen in the soil, benefiting subsequent crops. This sustainable farming practice helps maintain fertile soils for the long term.

4. Market Opportunities: Diversification can open up new markets and opportunities. Different crops or value-added products may have diverse market demands and consumer preferences, allowing farmers to tap into niche markets or premium prices.

5. Value Addition: Processing or adding value to agricultural products can significantly increase their market value. For example, turning fruits into jams, vegetables into pickles, or milk into cheese can bring higher returns compared to selling raw produce.

6. Resource Efficiency: Combining crops and livestock in an integrated system can make more efficient use of available resources. Livestock can provide manure for crop fertilization, while crops can provide feed for the animals. This integrated approach can optimize resource utilization.

7. Environmental Stewardship: Diversification can support environmental sustainability by promoting biodiversity and reducing the need for chemical inputs. Agro forestry, for instance, can enhance biodiversity and help sequester carbon.

8. Climate Resilience: Climate change is leading to more extreme weather events. Diversification can make a farm more resilient to these changes by

spreading the risk and adapting to new climate conditions.

9. Long-Term Farm Viability: Diversification can contribute to the overall viability and longevity of a farm. By mitigating risks, stabilizing income, and adapting to changing circumstances, diversified farms are often better equipped to survive in the long run.

10. Regulatory Compliance: Some regions have regulations that promote diversification as a part of sustainable agricultural practices. Diversified farming can help farmers comply with these regulations and access related incentives or grants.

11. Local Food Systems: Many consumers are increasingly interested in buying locally produced foods. Diversification allows farmers to tap into local food systems, meeting consumer demand for fresh, diverse products.

12. Innovation and Learning: Diversification encourages farmers to learn and innovate. Managing multiple crops or livestock species can lead to new knowledge and skills, fostering a culture of continuous improvement.

While agricultural diversification can offer numerous benefits, it's essential for farmers to carefully plan and manage these diversification efforts to ensure success. The specific reasons for diversification may vary depending on the farm's location, resources, market conditions, and the farmer's goals.

Key benefits of diversification:

Diversification offers a wide range of benefits in various contexts, from finance to agriculture to business. Here are some of the key benefits of diversification:

1. Risk Reduction: Diversification spreads risk across different assets or activities, reducing the impact of poor performance in any one area. This risk reduction is one of the primary advantages of diversification.

2. Enhanced Stability: Diversified portfolios or businesses tend to be more stable and less susceptible to market fluctuations. This stability can lead to more consistent performance over time.

3. Smoother Returns: By investing in a variety of assets or businesses, diversification can result in smoother, more predictable returns. This is particularly important for long-term investors and businesses looking for a steady income stream.

4. Protection against Volatility: Diversification can help protect against the extreme volatility that can affect specific markets or industries. When one sector is performing poorly, another may be performing well, balancing out overall returns.

5. Improved Risk-Return Trade-Off: Diversification can often enhance the risk-return trade-off, allowing investors to achieve a given level of return with lower risk or a higher return for a given level of risk.

6. Capital Preservation: Diversification can help protect capital and assets from significant losses, preserving wealth and investments over the long term.

7. Market Exposure: Diversification provides exposure to multiple markets, sectors, or asset classes, which can lead to a broader range of opportunities for profit and growth.

8. Liquidity: Diversifying investments across assets with different liquidity profiles can provide access to cash when needed, even if certain assets are less liquid.

9. Tax Efficiency: Diversification can be used to manage tax liabilities, as different investments may have different tax consequences. This can lead to more tax-efficient portfolios.

10. Long-Term Wealth Building: For long-term investors, diversification can be a powerful tool for building wealth steadily and consistently over time.

11. Mitigation of Specific Risks: In business, diversification can reduce dependence on a single product, service, or customer, mitigating specific risks associated with these dependencies.

12. Competitive Advantage: Diversified businesses can leverage complementary assets, skills, or technologies to gain a competitive advantage in the market.

13. Innovation: Diversification encourages innovation by exposing individuals or organizations to different ideas, markets, and experiences.

14. Adaptation to Changing Conditions: Diversification allows individuals and businesses to adapt to changing economic, market, or environmental conditions more effectively.

15. Sustainability: Diversification can contribute to the sustainability of farms and businesses by reducing reliance on a single source of income or a specific set of resources.

16. Risk Management: In insurance and risk management, diversification is used to minimize the potential impact of adverse events by spreading risk across different types of policies or clients.

It's important to note that while diversification can offer significant benefits, it also requires careful planning and management. Over-diversification, where there are too many assets or activities, can dilute the potential for substantial gains. The optimal level of diversification will vary depending on the specific goals and risk tolerance of the investor, business, or individual.

Types of non-farm employment in rural areas

Non-farm employment in rural areas refers to job opportunities and economic activities that are not directly related to agriculture. The expansion of non-farm employment is an essential component of rural development, as it can reduce dependency on agriculture, increase income, and provide economic stability. Various types of non-farm employment in rural areas include:

1. Off-Farm Wage Employment: These are jobs in rural areas that are typically outside of agriculture, such as working in rural industries, construction, retail, and services. Examples include working in local shops, construction projects, or small-scale factories.

2. Micro and Small Enterprises: Rural areas often have small-scale businesses, such as small manufacturing units, food processing units, and handicraft production. These provide employment opportunities to local residents and contribute to the local economy.

3. Cottage Industries: Cottage industries involve the production of goods on a small scale, often within the home or small workshops. They can include handloom weaving, pottery, basket making, and traditional craft production.

4. Rural Retail and Trade: Rural retail businesses, including grocery stores, clothing shops, and local markets, create employment opportunities for residents and serve the local community.

5. Livestock and Dairy Farming: While related to agriculture, non-farm employment opportunities can be found in livestock and dairy farming, which involve activities like animal care, milk processing, and marketing of dairy products.

6. Handicrafts and Artisanal Work: Many rural areas have a rich tradition of handicrafts and artisanal work. This can include pottery, weaving, woodworking, and other crafts that provide employment for local artisans.

7. Renewable Energy and Environmental Services: As the demand for renewable energy and environmental sustainability grows, there are opportunities for rural employment in areas like solar panel installation, wind energy maintenance, and sustainable land management.

Non-farm employment is essential for rural development, as it can reduce poverty, create economic diversification, and enhance overall quality of life. These opportunities can also help in mitigating the challenges associated with seasonal agricultural work and fluctuations in farm income.

The impact of diversification in agriculture

Diversification in agriculture can have a significant impact on enhancing farming income. By varying the range of crops, livestock, or agricultural activities, farmers can experience several positive effects: risk reduction, income stability, market opportunities, value addition, resource efficiency, environmental sustainability, climate resilience, market trends and consumer preferences, long-term farm viability, resource independence, innovation and learning, and community and local economies. While diversification in agriculture offers numerous benefits, it's important for farmers to carefully plan and manage these efforts to ensure they enhance farming income and long-term sustainability. Additionally, risk management strategies and market research are crucial components of successful diversification.

Conclusion

A complex approach, agricultural diversification entails raising a wider variety of animals and crops on a farm or in a region. Agricultural diversification is a dynamic and adaptive strategy that holds promise for addressing various challenges in agriculture. It has garnered attention and importance because of its potential to improve food security, boost farm resilience, and promote sustainable agricultural practises. Agricultural systems that are more resilient, inclusive, and sustainable can be achieved through the implementation of policies and practises that promote diversification. Nonetheless, it is critical to understand that local contexts, farmer expertise, and supportive policies are just a few of the variables that affect how successful diversification efforts are. In general, encouraging agricultural variety is a step in the direction of creating a future food system that is more resilient and sustainable.

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Consequences of Nano Urea in Bihar

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Nano Urea was the first breakthrough solution presented by IFFCO to address the problems associated with using urea. Aiming to improve crop yields, enhance soil fertility, and make farmers' lives more fulfilling, IFFCO has been working for farmers for five decades. Ramesh Raliya is the scientist behind nano urea. Since 2019, he has been active in the nationwide trial of nano urea, and has been developing nano urea since 2015. Nano Biotechnology Research Center (NBRC) at IFFCO, Kalol, Gujarat, developed the innovative product.

Nano farming is a promising path to a sustainable agriculture, and nano sized fertilizers are one of the new frontiers. Nano Urea manufacturing provides a simple method to develop nano scale materials for better crop production while minimized agrochemical leaching. Compared to 1 mm urea, Nano Urea (Liquid) contains nitrogen particles that are 10,000 times larger and contain much more surface area (10,000 times more nitrogen particles). As a result of the use of nano urea (liquid), yields, biomass, soil health, and nutrient quality are improved.

Technical specifications

- Major characteristic features of the Nano Urea are as follows: Nano urea prepared by nanotechnology contains nano scale particles of Nano Urea. Particles of Nano Urea have a size between 20 and 50 nanometers on average. Nitrogen makes up 4% of Nano Urea by weight. Nano Urea contains enough nitrogen to meet the crop's nitrogen needs. The use efficiency of this product is better than that of conventional urea. Most plants/crops can benefit from nano urea as a nitrogen source.
- Nano DAP (Diammonium phosphate): Developed by IFFCO it provides nitrogen and phosphorus to plants. Nano DAP (Liquid) has particle size less than 100 Nanometre (nm) which enables it to enter easily inside the seed surface or through stomata and other plant openings. A notable property of DAP is the alkaline pH. DAP also acts as a fire retardant. For example, a mixture of DAP and other ingredients can be spread in advance of a fire to prevent a forest from burning. DAP has chemical formula $(NH_4)_2$ (HPO_4) is one of a series of water-soluble ammonium phosphate salts.

Benefits of Nano Urea (liquid) has manifold benefits

1. More than 50% reduction in conventional urea requirement
2. It is equivalent to one bag of urea when one bottle of Nano Urea (500 mL) is used in place of one bag of urea, while taking up less space and producing more.
3. An eco-friendly product helps to address global warming and to meet UN Sustainable Development Goals by improving the soil, air, and water quality.
4. Cheaper than conventional urea.
5. An increase in farmer income is achieved by reducing input costs.
6. Produces higher crop productivity and greater soil health.
7. The Nano Urea was developed to provide a safer alternative to conventional urea, which can reduce its demand by at least 50%. Nitrogen is present in an amount equivalent to that of one bag of conventional urea, which contains 40,000 parts per million (ppm).
8. Farmers throughout India conducted around 11,000 field trials on more than 94 crops to determine its efficacy. The results showed an average increase of 8 percent in crop yields.
9. Agricultural researchers at 20 ICAR research institutes, State Agriculture Universities, and Krishi Vighyana Kendras have undertaken field trials on 43 crops in order to include nano urea in the government's Fertilizer Control Order.

10. With the new nano urea liquid, crops with improved nutritional quality can be produced more effectively. It may also reduce pollution caused by excessive application of the granular form, which intensifies soil, water, and air pollution in addition to climate change. In addition to being cheaper than conventional urea, the new product reduces the environmental pollution caused by excessive usage of the granular form.
11. There are 30 nanometers of surface area per gram of nano urea liquid particles, which gives the nano urea liquid 10,000 times more surface area than conventional granular urea. Spraying nano urea liquid on plants' leaves can make it more effective since it is ultra-small and has good surface properties.

Challenges for Nano Urea

- A bottle of nano urea is Rs. 10 cheaper than the 45 kg bag of conventional urea that costs Rs. 250. If we include labour cost of spraying then nano-urea costs Rs. 440 per bottle.
- Small and marginal farmers might not be able to adapt to liquid nano fertilizers since spraying equipment is costly and farm holdings are also small.
- For approving any new fertilizer, the Indian Council of Agricultural Research (ICAR) must have data for at least three seasons. Though field trials were undertaken for 94 crops over four seasons, data for three seasons is not available for any single crop.
- Effect of Nano Urea over varied crops in the country is not yet studied.

Urea crisis in Bihar

In October and November, the state received approximately 68% of its allotted urea supply, which means the urea supply was 30% and 36% short, according to Bihar agriculture secretary N. Saravana Kumar, who said the department had increased monitoring and surveillance of urea distribution. It has been reported that urea has been in short supply in Bihar, forcing farmers to purchase the fertilizer at higher prices. According to the government, urea was available for 290-325 for a 45-kg bag, compared to the maximum retail price (MRP) of 266.50. Farmers allege black marketing as one of the main reasons for fertilizer shortage in their respective villages. Apart from the National Fertilizers Limited (NFL), none of the other companies pay rent to transport fertilizers from the racks to the shops because of which it gets challenging to sell urea at a fixed rate, i.e. Rs.266/bag. To compensate for this additional expense, shopkeepers often try to sell fertilizers at Rs.340 or more.

Indian Farmers Fertilizer Cooperative Limited (IFFCO) manufactures 'nano urea', which has been marketed as a fertilizer to farmers in the face of a fertilizer shortage. IFFCO Nano Urea was virtually flagged off from Kalol to Bihar-by-Bihar Agriculture Minister Amrendra Pratap Singh. Bihar's Bettiah district is scheduled to receive the first batch of Nano urea. At present, the Kalol plant dispatches one truck containing 15000 bottles of Nano Urea every day, and within a couple of months, it will dispatch 10 trucks. In addition to saving the Government a staggering Rs 35,000 crore in subsidies, the Kalol plant produces a whopping 6750 tonnes equivalent of urea per day, which would help farmers earn an additional Rs 35000 crore.

The Phase-II expansion of the project will commission four more plants by 2022-23, resulting in an additional 18 crore bottles being manufactured. Nano Urea has been tested on over 11000 locations, 94 crops, and 20 institutes and universities affiliated with the Indian Council of Agricultural Research (ICAR). Crop diversification, doorstep delivery of veterinary services, increase in food grain production, and better agricultural marketing are emphasized in the fourth edition of the agricultural road map launched in Bihar on April 1.

Future Prospects of Nano Urea

Nano Urea is ready to revolutionize farming with its high efficiency and minimal environmental effect. As farmers grow a high yield of crops at a low cost with this sustainable replacement of fertilizers, their income is likely to increase. It is becoming increasingly common for several Indian states to use sustainable methods to supplement nutrients to crops. One state, Telangana, has pushed Nano Urea on a large scale and has used it extensively. In addition to distributing the product to farmers worldwide, India plans to market the product in the developing world. The Sri Lankan government received 100 tonnes of nano urea recently. During the period when chemical fertilizers were stopped from being imported by the government of Sri Lanka, nano urea became urgently needed. India is leading the world towards a thriving, healthy, and sustainable future with the rest of the world.

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A Case Study on Geographical Indication Tagged Sirarakhong Hathei Chilli – An Economic Analysis

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Chilli (*Capsicum annum* L.) is an essential spice cum vegetable crop in India. India is rich in chilli biodiversity but many of the wild varieties of chilli are found in northeastern region of India. Sikkim's round cherry pepper, Assam's ghost chilli, King chilli of Nagaland, Mizoram's bird eye chilli, Manipur's Hathei chilli *etc.*, are some of the wild chilli varieties those are cultivated in this region.

The well-known Hathei chilli is found only at Tangkhul Naga inhabited Sirarakhong village near Mahadev hills in Ukhrul district of Manipur which has favourable conditions for its growth. In Tangkhul dialect bitterness is referred to as 'ha' and fruit is referred to as 'thei'; thus, the name is 'Hathei'. It is considered one of the best varieties of chillies in the world because of its taste, colour, flavour, length, softness, etc. Hence, it is called 'Pride of Ukhrul' and 'God's Gift' by the people of Sirarakhong village. Because of its unique characteristics, it was awarded a Geographical Indication (GI)Tag in 2021 which offers a better platform for obtaining premium price in the market.

Hathei chilli considered to have good health benefits. It is rich in anti-oxidant (Total flavonoids = 74.86 mg QE/g), calcium content (465.25 mg/kg) and vitamin C (2.0g/100g). This chilli had the lowest capsaicin content of 0.05 per cent compared to Naga King chilli of 0.55 per cent (Ananthan *et al.,* 2014). Dry chilli is widely used as spice for all the meat curries as Manipur is considered one of the meat-consuming states of India. It improves the colour and flavour of all the dishes naturally as similar to Kashmiri chilli.

We have conducted a case study in 2022 at Sirarakhong village. The primary information regarding its origin, cultivation practices, GI tag certification, economics and constraints were collected by interviewing 15 Hathei chilli cultivators. The total fixed and variable costs were identified and the per hectare cost and returns of Hathei chilli were estimated. Acharya and Agarwal method (Acharya and Agarwal, 2007) was used for analysis of marketing efficiency of chilli.

How they started cultivating Hathei chilli?

Ancestors of Sirarakhong village collected the plant while going for hunting and raised it in their home without knowing that it was a chilli plant. Later when the plant blossomed and set fruit, it was recognised to be chilli plant. Since then, the raising of Hathei chilli in the village has evolved and cultivation of this chilli has become the primary source of income for the villagers. At present about 1243 farmers from 200 households produce approximately 5000 kilograms of chilli from around 18 hectares of area per year. In every six months, each household harvests around 300 kilograms of chilli in one season (Khapudang and Bose, 2022).

Hathei chilli also has a link to cultural life of the people. They have a song representing Hathei chilli which describes it as 'red cover' over the hills which was given by the ancestors of villagers. They organise 'Hathei Phanit' (Hathei chilli festival) every year since 2010 to celebrate its quality and belief that its God's gift to the villagers of Sirarakhong. The main purpose of this chilli festival is to attract the buyers of this chilli from various parts of India. Also, this festival symbolizes the time of harvesting in Sirarakhong.

How Hathei chilli got GI tag?

In 2015, farmers of Sirarakhong village formed a group and decided to protect their gift of nature as well as their income from Hathei chilli cultivation. In 2017, an application made by Manipur Organic Mission Agency (MOMA) at Directorate of Horticulture, Manipur for GI registration submitted to Geographical Indication Registry in Chennai.GI tag is an intellectual property right that recognizes the unique qualities and characteristics of a product originating from a particular geographical region. Further, the application under the name 'Hathei chilli' falling under the class-30 accepted in 2020 under sub-sec (1) of section-13 of Geographical Indication of Goods (Registration and Protection) Act, 1999. The GI tag is helping the farmers of Sirarakhong village to preserve and promote their traditional variety of chilli which was the verge of extinction due to the emergence of hybrid and imported varieties. It has also given the farmers a distinct identity and recognition in the market which has helped them to command a better price of their produce.

Cultivation practices followed by villagers

Hathei chilli is cultivated widely under jhum or shifting cultivation on the hill slopes of Sirarakhong village. Raised beds are prepared manually and covered with farm waste, manures, etc. The most preferred soil for Hathei chilli cultivation is well drained light soil varying from loamy to sandy loam. Seeds from the previous year's crop are traditionally preserved for next year's sowing. Cultivators sow their seeds in raised bed nursery under polyhouse structure during the month of March and April. The seedlings are transplanted to the main field after 30-40 days of sowing. It is grown as a rainfed crop, the suitable time for transplanting is rainy season *i.e.,* May-June. The high amount of rainfall for the period of six to eight months helps the cultivators grow Hathei chilli without irrigation.

Due to jhum cultivation, weeds and diseases are controlled during the initial phase but after that the crop requires frequent weeding. We found that they do not use any herbicides for weed control. Since the cultivation takes place in forest area, the soil is highly fertile and therefore cultivation is done without inorganic fertilizers. Besides, jhum cultivation ensures more potash availability which help the crop to grow well and provides good colour to the chilli fruit. Harvesting of chilli fruits start from July-August onwards. It is harvested green or left to ripen on the plant. The ripen harvested fruits are sun dried or dried with the help of local furnace with proper stirring. The dried chillies are packed and stored in a dry place. Some of the farmers grind the chillies by using pestle and mortar and sell after proper packing in plastic bags.

Table 1. Cost of cultivation of Hathei chilli per hectare

Sl. No.	Particulars	₹/ha	%
A.	**Variable cost**		
1	Hired labour	6541	24.95
2	Family labour	4900	18.69
3	Seed	437	1.67
4	Manures	703	2.68
5	Fertilizer	738	2.81
6	Organic pesticides	1285	4.90
7	Interest on working capital	5111	19.49
	Sub-total (A)	**19714**	**75.19**
B.	**Fixed cost**		
1	Depreciation on farm implements	719	2.74
2	Land revenue	0	0.00
3	Rental value of leased in land	2797	10.67
4	Interest on fixed capital	2989	11.40
	Sub-total (B)	**6505**	**24.81**
C.	**Total cost (A+B)**	**26219**	**100**

Cost and returns of Hathei chilli cultivation

Table 1 indicates that the total cost of Hathei chilli cultivation was ₹ 26219.14/ha. The share of variable cost in total cost was found maximum (75.19%) while the share of fixed cost was 24.81 per cent. The share of hired labour wages in total cost was maximum (24.95%), followed by a share of interest on working capital (19.49%) and family labour wages

(18.69%). The expenditure incurred on organic pesticides, fertilizer, manure and seed were less than 5per cent to the total cost. The share of seed cost was found to be least as the farmers preserve their own seeds from previous year's chilli crop for future use. Among the fixed expenditure, interest on fixed capital contributed maximum to the total cost share (11.40%), followed by rental value of leased in land (10.67%) and depreciation (2.74%).

Income from Hathei chilli cultivation on per farm basis is presented in Table 2. The per hectare gross farm income and net farm income from Hathei chilli cultivation was estimated to be ₹ 70031/ha and ₹ 26219/ha, respectively. The benefit cost ratio was calculated to be 1: 2.67.

Table 2. Income from Hathei chilli cultivation on per hectare basis

Sl. No.	Particulars	₹/ha
1	Gross Farm Income	70031
2	Total Cost	26219
3	Net Farm Income	43812
4	Benefit-Cost ratio	2.67

Marketing of Hathei chilli

The villagers sell the chilli as green in the case of first harvest due to lower yield. From the second harvest onwards, cultivators leave the chillies in plants until it become dark red in colour, which is the maturity index for processing as dry chilli. They do not get much incentive to sell their produce directly to consumers in distant markets due to scattered villages low population density, lack of accessibility and high perishability. The fresh green chilli fetches less value in compared to dry chilli.

The Hathei chilli cultivator sell their produce primarily in two major markets *i.e.,* Ema market in Imphal and Ava market in Ukhrul. Three marketing channels for dry chilli were identified during our interview. The three channels were as follows.

Channel I: Producer → Wholesaler→ Retailer→ Consumer

Channel II: Producer → Retailer → Consumer, and

Channel III: Producer→ Consumer

Table 4 reveals that marketing cost of Hathei chilli was the highest in case of Channel I (₹ 36/kg), followed by Channel II (₹ 14/kg) and Channel III (₹ 7/kg). Marketing margin earned by different intermediaries was highest in case of Channel II (₹ 554/kg), followed by Channel I (₹ 382/kg) and price received by the producers was the highest in case of Channel III (₹ 900/kg). Consumer paid ₹ 1233, ₹ 1467 and ₹ 960 per kg in Channel I, Channel II and Channel III, respectively. So, the price spread was found to be highest in Channel II (₹ 590/kg) and the lowest in Channel III (₹ 60/kg).

Even though the marketing of Hathei chilli through Channel II was the most preferred by the Hathei chilli cultivators, the producer under this channel realised only around 60 per cent of share in consumer's rupee and efficiency was found to be the lowest (1.59) which is not reasonable from the point of view of efficient marketing. The marketing efficiency for Channel III was the highest (15.43).

Table 4. Marketing cost, margin, efficiency and price spread in different marketing channels (₹/kg)

Sl. No.	Particulars	Channel I	Channel II	Channel III
1	Net price received by producer	815	876	900
2	Marketing cost	36	14	7
3	Marketing margin	382	554	53
4	Price paid by the consumer	1233	1467	960
5	Price spread	418	590	60
6	Efficiency	1.96	1.59	15.43
7	Producer share in consumer rupee (%)	66	60	94

Constraints and suggestions by Hathei chilli cultivators

Our interview revealed that Hathei chilli cultivators of Sirarakhong village faced various constraints related to production as well as marketing. Since it is a native variety, its yield is lower compared to other hybrid varieties of chillies. Due to topography, high altitude, distance and the lack of accessibility of agricultural land, modern crop management practices could not be followed in this village. The high incidence of weeds led to the maximum expenditure incurred on human labour for the weeding operation alone which increased the total cost of cultivation. Pest incidence was also high since they follow a natural way of cultivation. Poor road condition and transportation facility, high altitude and less storage facilities were the different marketing constraints faced by the Hathei chilli cultivators.

Conclusion

This case study reveals that Hathei chilli is at the heart of Sirarakhong village and it bears economic significance for the farmers of the village. The crop is cultivated organically which makes the cultivation of this chilli profitable as it fetches relatively higher price at market. Though this variety has got GI tag but the potential of it is yet to be realized by the farmers of the village. Efforts to market it at national and international market are required. Marketing strategies viz., better packaging, branding and advertisement need to be prioritized so as to take the full benefit of this native variety of chilli.

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Applications of Drone Mounted Sprayer for Weed Management

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The global population of 7.7 billion is expected to reach 9 billion by 2050 which may lead to acute shortage of food (www.fao.org). To overcome this problem there is need to increase in the food production. Major constraints in crop production is nutrients management, pests control and weed management (Ghera, 2013). Weeds are major problem in which grow in agricultural crop and it can reduce crop yields by competing for water, nutrients, light, space, & carbon dioxide which leads to yield losses. The conventional weed control methods- manual, mechanical, chemical & biological are popular in which manual/mechanical method (bare hands, bare held, hand operated, sprayer tools) are best but labour intensive and time consuming. Chemical application is most used technique by manual sprayer and engine operated sprayer. Those having some disadvantage in field like chemical wastage, non-uniformity, labor, crop damage and health issue of farmer. The concept of precision and smart agriculture through application of drone technology solution is imperative (roslim *et al.*, 2021). The role of drone technology in weed management is weed mapping and on spot spraying. Weed mapping is used for the site-specific weed management through different image capturing sensors and image analysis software. The early weed detection by mapping which allows to take immediate action, saves on chemical, reduces cost, benefits the environment, prevents soil nutrient competition, reduces crop stress, improves yield and also the remote pilot aerial system for weed management reduces the physical efforts of farmer along with time saving, reduces labor, improves work efficiency, reduces chemical wastages, getting higher yield and reduce health issue (prabhu *et al.*, 2021).

Drone mounted sprayer

Drone is common name for unmanned aerial vehicles/system. Drone stands for dynamic remotely operated navigation. Drone is a remotely piloted aircraft controlled directly by a human operator via radio link, or with various levels of autonomy achieved by using autopilot technology. Drone mounted sprayer is combination of drone and sprayer unit with sensing cameras.

Working of drone mounted sprayer

The signals will be transmitted from transmitter and it will be received by the receiver in the drone. From the receiver the signal goes to the flight controller where the signal will be processed with accelerometer and gyroscope sensors. The processed signal will be sent to the ESC, which allows the specific amount of current to the motor based on the signal it receives. The propellers are mechanically coupled to the motors so that they rotate and produce thrust. The FPV camera takes current supply from the flight controller and it records the video, the video signals will be processed by the transmitter and it will be received by the receiver in ground. The pump takes current supply from the Li-Po battery and pressurizes the liquid from the storage tank then the pressurized liquid flows through the pipeline and enters the nozzle then gets sprayed. The flow rate of the pump can be controlled by varying the input current which can be controlled by transmitter.

Functions of drone mounted sprayer

1. Spraying of chemical

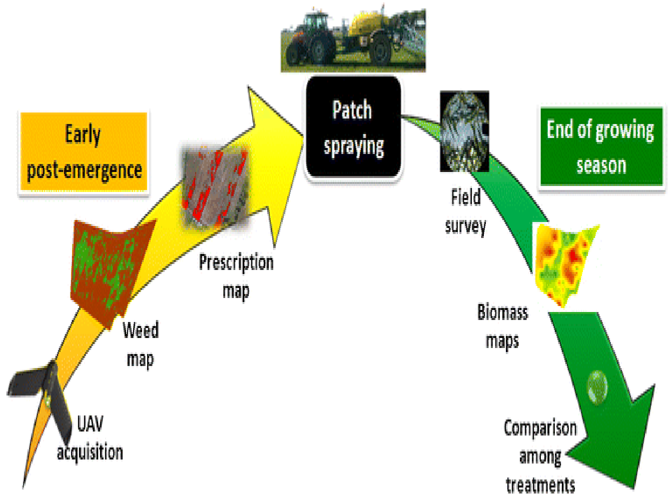
Drone is equipped with spraying tank in which spraying of chemical done by pumps in which instructed by pilot. It is most commonly used drone mounted sprayer because of less price. Most of drone carry 5 liter to 20 liter of spraying chemical with field capacity of 0.5 ha to 2 ha.

2. Weed detection, mapping and on spot spraying

Weeds grow in the form of patches of crop field. Conventional method weeds detection and weed management is time consuming. The different patterns of weed appearance within the field require subsequently customized crop management for targeted treatment application. In manual control of weeds and chemical application equipment or sprayer

need more time, labor and herbicide wastage. Overcome this problem special technique called drone equipped with sensors for detection and machine learning software for weed recognition. Sensing equipment and AI are under developed for real time identification of weeds hence enabling site specific treatment with high accuracy. For applying most appropriate dosage of chemical weed mapping is required. The efficient combination of UAV and Sensors system is solution for weed mapping with best image processing software. Different types of sensors used for drone technology are RGB, Infra-red sensors, multi spectral sensors and hyper spectral sensor. Most of software used for weed mapping nothing but Orthomosaiking software – ArcGIS, QGIS, OBIAPIX4D, DroneDeploy, Sentera.

Source: Castaldi *et al.*, (2017)



Advantages of drone mounted sprayer

- Low cost of operation
- High efficiency of work
- Save labour cost
- Reduced health issue
- No damage to crop
- Uniformity of spraying
- Saves chemicals

Limitations

- Flight time and flight area
- Heavy cost for good feature drones
- Safety in operations
- Not suited for very small area
- Knowledge and skill

Challenges

- Extend battery life
- Variety of UAV types
- Research data on reliability is missing
- Weather robust
- Safety issues

Conclusions

The use of remote imagery captured by unmanned aerial vehicles has tremendous potential for designing detailed SSW control treatments in early post emergence. The prescribed maps data transferred to other system for further use. It helps to calculate the herbicide requirements and estimation of the overall cost of weed management practices. It also helps to repeatable data to analyze field. The saving of herbicide calculated in patch spraying around14 to 39.2% and saves cost of chemical operation. To overcome all problems this technology is best for future generation.

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Table 1: Components of drone mounted sprayer

SI.No	Component	Its function and material use	Picture
1.	Frame	➢ It is a main structure of drone to which all parts get assembled ➢ It is combination of alloys	
2.	Landing gear	➢ It helps for safe landing of drone on the ground ➢ It is made of iron/ steel	
3.	Battery	➢ It is used supply the power to drone of flight controller and pump	
4.	Flight controller & Remote controller	➢ It is helps in the maneuring operations and also it provides auto level function ➢ Transimites and receives the signal ➢ It is an electronic circuit	 

5.	BLDC Motor	➢ It helps to produce RPM to propeller ➢ it is made of carban fiber and wire mesh	
6.	Electronic speed controller	➢ It varies the speed of propeller	
7.	Propeller	➢ It is used to develop thrust to take off and take on of drone ➢ It is made of high carbon fiber	
8.	Tank	➢ It is used to store the liquid ➢ It is made of plastic	
9.	Pump system	➢ To pressure the liquid ➢ It is made of plastic	
10.	Nozzles	➢ It helps to spray the liquid in finer droplets ➢ It is made of plastic	
11	Sensors	➢ It helps to capture the image of ground at high resolution pixels	
12	Camera system & Video system	➢ It helps to transmission of video signal to receiver	

Source: Shaw and Vimalkumar., (2020)

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Speed Breeding in Vegetable Crops

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In conventional plant breeding, the parents that will make the best offspring are crossed. Following that, parents are chosen and screened for the desired attributes. This process takes a lot of time. The selected materials for generation advancement are responsible for the long time. Therefore, the development of a new variety takes 8–10 years. Every plant in this place has undergone this gradual process of improvement. Accelerating research and speeding up cultivar development are both necessary to maximize the stability and production of crops to cope with changing climatic circumstances. Every crop requires some time to modify its breeding and generational plans, thus it is necessary to develop and make use of technology that can speed up the growth of plants. Speed breeding can be used to solve this fundamental issue.

Speed breeding, a cutting-edge technology created by Lee Hickey and colleagues to overcome all these disadvantages, shortens the breeding cycle and speeds up crop improvement through frequent generation cycling. Speed breeding was used to create the first spring wheat variety, "DS Faraday," which was introduced in 2017 in Australia. It is a method of plant breeding intended to hasten the creation of new crop types. It entails modifying the growing environment of plants to encourage quick development and shorten the time needed to finish a reproductive cycle. Speed breeding's main objective is to create several generations of plants in a year, which enables the creation of new crop types and the quicker selection of desired features. The first crops were agronomical ones in which speed breeding is applied. However, it is now also feasible for horticulture crops. Vegetable crops are just one of the many crop plants that can benefit from speed breeding. This method has been used to generate 6 generations and 4 generations annually. *Pisum sativum* (pea), *Hordeum vulgare* (barley), *Triticum aestivum* (spring bread wheat), *Triticum durum* (durum wheat), *Cicer arietinum* (chickpea), and *Brassica napus* (canola) were the first plants to adopt this technique. Research is being done on carrot, tomato, and cauliflower. Crops produced using a speed breeding technology go through a typical developing phase. It has a high seed germination rate and is easily or quickly crossed.

Speed breeding setup

The following are the primary environmental factors for setting up fast breeding technique:

1. Temperature
2. Light
3. Photoperiodic regime
4. Humidity

Comparison among different approaches

- **Exerting physiological stress** – It entails limiting plant growth, limiting nutrients or water, and thinning the plant canopy, which will cause early flowering and seed germination. Example: Pea instance demonstrated.
- **Embryo rescue** – It involves inducing embryos to germinate on culture media in vitro, either with or without the use of PGRs. **Example:** Ochatt *et al.* (2002) and Mobini and Warkentin (2016) reported that without PGR it required 6.9 and 5.3 generation each year, respectively, however Mobini *et al.* (2015) sprayed PGR to stimulate early flowering and embryo rescue in faba bean and obtained up to 6.5 generation per year. Furthermore, fast breeding without embryo rescue can provide 6 generations of pea every year.
- **Carbon concentration (%) –** Increasing the CO_2 content can also encourage plant growth.
- **Double haploids –** Extensively and frequently used in the breeding of numerous crop species, requiring only two generations instead of six or more to produce homozygous lines. However, it has some drawbacks, including expensive techniques, a need

for specialized knowledge, and a variable success rate that might be genotype-specific. Notably, by accelerating the procedures of crossing, plant regeneration, and seed multiplication, speed breeding has the potential to expedite the development of DH lines even more.

Speed breeding in vegetable crops

Extending the photoperiod has shortened generation intervals in vegetables, such as pepper, tomato, and amaranth, which respond effectively to increased daylight. In tomato, germination of immature seeds from different maturity levels provided new possibilities to achieve five generations instead of the conventionally grown three (Bhattaraj *et al.*, 2009). Similarly, in pepper and tomato, in vitro germination of immature embryos enabled authors to obtain one more generation compared to conventional breeding practice (Manzur *et al.*, 2014). In grain amaranth, photoperiod manipulation was reported to be helpful in flowering synchronization in different germplasm lines, which, in combination with DNA marker technology, led to the development and identification of true hybrids, thus, accelerating the breeding program (Shetter *et al.*, 2016). Other methodologies that can improve generation turnover in vegetables by promoting early flowering involve higher expression of flowering genes such as the CaFT-LIKE gene in pepper (Borovsky *et al.*, 2020). Similarly, in tomato, introgression of the gene CAB-13 can impart tolerance to continuous light, thus, adapting plants to extended photoperiods (Velez-Ramirez *et al.*, 2014).

Applications

1. Rapid generation of Breeding population.
2. Development of mapping populations. Example – RILs have been developed in case of pea.
3. Mutation studies
4. Gene introgression using MAS
5. Accelerating the rate of crop improvement.
6. High throughput genotyping
7. Speeding up the conventional approaches.

Limitations of Speed Breeding

- Under prolonged photoperiods, the time to flowering is frequently accelerated in long day plants. Conversely, short day plants need photoperiods that are below the minimum necessary for flowering, which may not be compatible with rapid breeding circumstances.
- Limited phenotyping of some seed properties is the outcome of the further reduction in generation time. Phenotyping grain dormancy is an example.
- Plant injuries may be troubleshooting like chlorosis.
- Initial set-up cost is very high.
- Requires skilled person.

Conclusion

Researchers studying plants can now move their attention from model plants to crop plants thanks to recent improvements in genomic techniques and resources and the falling cost of sequencing. Despite these developments, a significant entry barrier still exists due to the lengthy production times of many crop species. Since speed breeding is a very versatile method, it uses prolonged photoperiods to hasten plant growth and the germination of immature seed, shortening the generation period. It is clear that speed breeding in conjunction with these techniques and resources will enable more plant scientists to conduct research on crop plants directly, further expediting crop improvement research. Additionally, a rapid generation advance may aid in the development of homozygosity after crossing, which will ease genetic gain for important traits and enable breeding operations to produce superior cultivars more quickly.

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Vertical Gardens - The Living Green Walls

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Vertical Gardening is a special kind of urban gardening suitable for small spaces, particularly for decorating walls and roofs in various styles. This is an alternative method for gardening by expanding the scope of growing plants in a vertical space. Vertical gardens have been around since 1938 when Stanley Hart White, a professor at the University of Illinois, developed the idea and created a patent for it. Forty years later, a French botanist named Patrick Blanc gave life to the idea of the modern green wall, specifically with a hydroponics irrigation system. Today, you can see green walls anywhere, from offices and cafes to shopping centers and hospitals.

Plants Suitable for Vertical Garden

Plant selection should be based on local climatic conditions. Plants should have compact growth habit which is likely to provide thick and dense cover. Plants with short growth habits should have shallow fibrous root systems and long-life cycles. Plants should be capable of coping with full sun or full shade according to the location.

The most commonly used plants in vertical gardens are Green Facades: *Hedera helix, Parthenocissus spp, Hydrangea petiolaris, Polygonum bauldschianicum, and Lonicera spp. Clematis spp. Aristolochia spp. Jasminum officinale, Passiflora caerulea, etc.*

Living Wall: Dracaena, *Phalaenopsis spp, Asparagus sprengeri*, Kalanchoe, *Cordyline spp. Chlorophytum spp., Haworthia spp., Tradescantia sp, Fittonia spp,* Nephrolepsis, *Clematis, Gardenia spp., Asplenium nidus, Maranta spp.*, Cotoneaster, *Euonymus fortune*, Hedera, Hydrangea, Lonicera, Parthenocissus, Polygonum, Pyracantha, Selaginella, Wisteria, Rose, Petunia, Nasturtiums, Daisies, Bromeliadsand even some vegetables like tomato, chillies, cucumber, peas lettuce, etc.

Exterior Wall: Lavendula, Thymus, Rosmarinus, or Salvia for full sunlight while Begonia, Arum, Davallia, Asplenium, and Fuchsia for shady locations.

Interior Wall: Philodendron, Epipremnum, Aeschynanthus, Columnea, Saintpaulia, Begonia, or different ferns like Nephrolepis, Pterisandmany species of Peperomia. (Ritu Jain., 2023)

Cocopeat, Perlite, Sphagnum moss, vermiculite, vermicompost, shredded bark, and leaf molds are the common growing media combinations used.

Features of a vertical garden:

In vertical gardening, use structures or columnar trees to create garden rooms or define hidden spaces ready for discovery. Trellises, attached to the ground or to large containers, allow you to grow vines, flowers, and even vegetables in vertical garden pots using much less space than traditional gardening requires.

Benefits of vertical gardening:

1. **Improve your physical and mental health**

Plants counteract respiratory diseases and improve cardiovascular problems by producing oxygen and purifying the air which reduces issues like breathing problems and blood pressure.

2. **Improved space**

A vertical garden is definitely a unique way to have your own urban garden or to arrange plants, and it also acts as a decorative element that brings a touch of nature to your spaces.

3. **Improvement of air quality**

The plants in a vertical garden filter particles from the air and convert carbon dioxide into oxygen. One square meter of plant space will generate the equivalent of a year's supply of oxygen for a human and trap 130g of dust.

4. **Insulate your building**

Vertical gardens also act as thermal insulators, this green solution lowers the temperature inside a building by up to five degrees, which means that less air conditioning is required, therefore saving energy.

5. **Reduce noise pollution**

Plants in vertical gardens are capable of absorbing up to 50% of the noise generated in a large city.

6. **Increasing amount of green space in the cities**

The speed of construction is increasing due to the urban population. Urban green spaces that offer recreational facilities for the people in urban areas are decreasing day by day.

7. **Adding aesthetic and economic value to the structures**

In our daily lives, we spend most of our time in areas built with gray walls is quite far from the aesthetic concept. People's living spaces are increasingly graying, with a reduction of available green areas in the cities. Vertical garden systems are involved in the aesthetic value of the landscape to which they apply.

The general advantages of vertical gardens are:

- ✓ Growing plants up, not out, in beds with a small footprint
- ✓ Less soil preparation and digging from day 1
- ✓ More plant variety and much less space
- ✓ Many opportunities to create bottom-up and top-down plantings
- ✓ Less weeding
- ✓ Space saving containers
- ✓ Improved air circulation
- ✓ Easier harvest
- ✓ Large yields in compact space
- ✓ Increased aesthetic appearance

Maintenance frequency and difficulty

Vertical gardens require regular maintenance. Maintenance frequency depends on the type of vertical garden, climatic conditions, and plant varieties. So maintenance is generally related to plant diversity and irrigation systems. But if there is a damaged carrier panel or isolation material they must be changed. As with all landscaping work the plants which convenient to environmental conditions must be used. However, if there is still damaged or dead plant they must be altered. Also, maintenance work is required for the irrigation systems not to be affected by frost during the winter months. It also should be realized that the addition of plant food materials and regular pruning work for the desired effect.

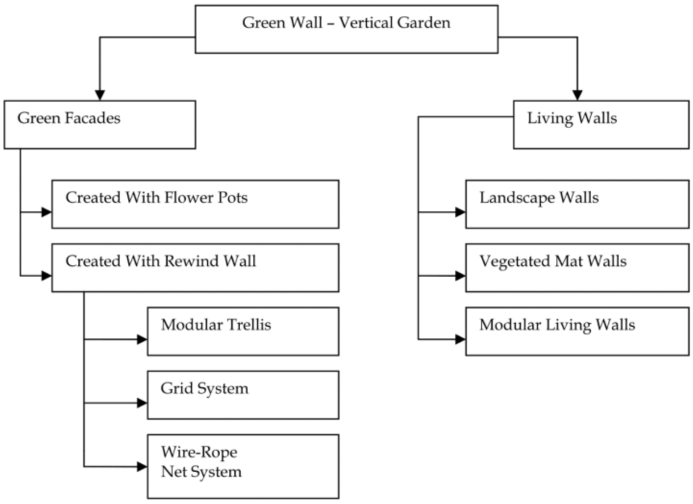
Expensive elements of the work that will be applied on a vertical surface are more than on a horizontal surface.

Expensive elements in the vertical garden are as follows:

1. Carrier profile
2. Isolation material
3. Drainage system
4. Plant growth media
5. Plant species
6. Routine maintenance costs

From an article given by Davis et al. (2017), Up to 44% of EU residents are exposed to noise levels that are detrimental to health. In this context, vertical gardens could play an important role in architectural acoustics, where the main absorber material is the substrate soil. Plants have a beneficial effect for higher frequencies when planted in a large density.

The objective was to ascertain and explain the random incidence sound absorption coefficient of vertical garden modules. 50 modules making up a total floor area of 10.125 m^2 were used for the measurements. Six different configurations were measured: connected versus dispersed and directly on the floor versus with an air cavity of 5 and 10 cm.



Furthermore, each configuration was tested with modules solely filled with substrate and with substrate-filled modules with densely planted ferns. The weighted random incidence sound absorption coefficient of the modules densely planted with ferns equals 1.00. This applied to all different configurations tested. The sound absorption coefficient in the lower frequencies (100–315 Hz), mid frequencies (400–1250 Hz), and high frequencies (1600–5000 Hz) was 0.59–0.80, 1.00 and 1.00 respectively. This makes this type of building technology highly suitable for applications where sound needs to be attenuated, paving the way for applying vertical garden systems as a design tool for improving the acoustics of indoor spaces or urban squares.

Major areas where we can see vertical gardens are:

1. Airports
2. Railway stations
3. Hospitals
4. Educational institutions
5. Offices

Hyderabad has the maximum number of vertical gardens in India. The initiative was taken up in an attempt to control pollution and add aesthetic value to the city. Hyderabad took care of the green wall by pre-installing a drip irrigation system. Beautify flyovers in the city with paintings and vertical gardens on pillars. Vertical gardens can be seen at flyovers located at various places in Hyderabad. More such gardens are likely to come up at other flyovers including the biodiversity flyover, Chandrayangutta flyover, and Kothaguda flyover.

Recently, Hyderabad won 'World Green City Award 2022' at the International Association of Horticulture Producers (AIPH) World Green City Awards 2022 held in Jeju, South Korea. The city won the award defeating popular cities likely Paris, Mexico City, Montreal, Fortaleza, and Bogota.

The innovative concept of vertical gardens was launched on either side of the main entrance of Tirumala temple on 2nd June 2016. The 30 lakh rupee project was initiated by the Hyderabad-based Harsha bio farm, free of cost to TTD for a period of one year. Later on, the firm trained the garden staff of TTD on planting techniques and maintenance. Meanwhile, over-foliated plants have been planted in 2500 pots with automatic drip watering facility. Whenever the plant needs water, the drip automatically wets the plants.

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Applications of Artificial Intelligence in Aquaculture

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Currently, Aquaculture plays a critical role in meeting the budding global demand for Aquaculture and fisheries products; however, it faces immense challenges in fish growth, seed production, feed utilization, health status and remote monitoring. With technological advancements, the artificial intelligence (AI) technique offers inspiring resolutions for enhancing fish farming practices and certifying sustainable aquaculture development. With this new sophisticated and dynamic artificial intelligence (AI) technique, we aim to convert aquaculture from art into more of a science. The utilization of modern AI technology significantly frees up human resources, upsurge current manufacturing efficiency, and aids in increasing output, product quality, and other conveniences. There are numerous applications of AI systems in aquaculture, and the important ones are listed:

Remote Automated Monitoring

With AI in aquaculture, the aquaculturist can remotely monitor and maintain the farming site. AI systems control cloud infrastructures to give remote site-level examination and glitch detection to levels never grasped before. AI systems will give alarming signals to farmers about water levels, any blockages, low oxygen levels or any other concern that might be important to resolve instantly. It helps the farmers to roam freely by remote monitoring and maintenance while being capable of monitoring their aquaculture sites with accuracy. The necessity to continuously remain present in the field is no longer possible due to AI only (Yongqiang *et al*., 2019).

AI-based Automated Feeding

As feeding represents the biggest cost to farmers, which involves more than 50% of input cost, optimization in this area always means better profitability. The use of AI-based Automated Feeding systems has revolutionized the feeding process in fish as the farmers have to fed fish manually, and feeding is a tiresome process. Remaining constantly available, farmers can occasionally forget, or they may even remain inaccessible for certain purposes. This is where AI can be extremely important and step into the fish farmer's shoes using automated feeding systems. This AI-based Automated Feeding system has AI-empowered tools that release a registered amount of feed at a particular time for fish to intake, minimize feed wastage and improve feed consumption among the fishes. The proximate composition of feed, its nutrient profile and energy content will be displayed all the time to improve the nutritional content and shelf life of fresh and processed fish products. It can also help fish products retain their natural flavours and aromas.

Examine growth and biomass.

The calculation of manual biomass in aquaculture gives significant challenges as it's time-consuming and tedious with no considerable enhancements. The correctness of these dimensions relies heavily on the worker's skills and knowledge, making them vulnerable to human error. Furthermore, physical measurements are characteristically restricted to small samples, which may provide an inaccurate representation of the entire fish population in ponds. This restriction results in errors when approximating the total biomass. In addition, frequent labour-intensive measurements cause stress, disrupt their feeding patterns and condition their health. By utilizing the power of AI, farmers not only identify the dodges in their cultivation practice but are aware of the upcoming steps and loss control to ensure that their fish stock turns out to be fruitful. It will contribute to the collection of big data and analytics to help others analyse the correct practices and steps for the same. Meanwhile, combining machine vision and machine learning can better assess fish size, weight, numbers, and other biological data (Zhao *et al*., 2021).

Water Quality management

Another important advantage of using AI in aquaculture is that it can easily detect water quality and regulate it. As we know, water quality is the main and important factor that determines the growth, health and survivability of fishes throughout the process of culture. Any contamination with water tends to infect the pond/water body. AI-empowered sensors can simply inform the farmer and lead to supervisory measures. This particular application of AI makes the aquaculture industry very advanced yet progressive.

Regulating Temperature

Temperature is one of the critical factors regulating the growth and development of fishes, and its regulation is important for the growth and experimental analysis of fishes. Temperature optimization can be done through artificial intelligence and machine learning algorithms that allow farmers to customary their preferences and extract modified models for their fish culture site. For example, AI can help farmers to increase it at night.

Human-less Filtration

In earlier times the filtration of aquaculture farmers manually to maintain the water quality, the contemporary era has become much more advanced. As Motorized by AI, human-less water filtration can be easily done with the help of pre-installed machinery. Hence, the practice of AI in aquaculture denies the need for farmers to manually perform tiresome activities and spend long hours in the same. At the same time, performing and monitoring all the functions to cope with the demands of culturing practices and lead to better outcomes for the practice altogether.

Data Analytics

One of the important applications of AI in aquaculture is that it can utilize big data analytics to collect information records and help others take the right steps. With the benefit of data analytics, farmers can very well recognize the risks and encounters that they might face in the process and take appropriate steps to ensure that they are on the right path. So, data analytics not only provides you with a summary of the practice but also capitulates the dos and don'ts to help farmers.

One of the chief applications of artificial intelligence, predictive analytics paves the way for aquaculture practitioners not only to strategize their upcoming actions but also work along the lines of the forecasted notions so that they can do the best for their cultural practices. Artificial intelligence is improving aquaculture by making farmers understand the analytics of how their inputs affect fish growth under various conditions.

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Cultivation Technologies of Capsicum

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Capsicum (Sweet pepper / Bell pepper) is botanically called as *Capsicum annuum* belongs to the family Solanaceae. This crop is suitable for growing in winter season in tropical areas and in shady places. It can also be suitable for intercropping in plantation crops which allows lesser sunlight in to the orchard. It is a high value low volume crop suitable for protected cultivation during off seasons.

Varieties

Arka Athulya, Arka Basant, Arka Gaurav and Arka Mohini are some important varieties of Capsicum released from Indian Institute of Horticultural Research, Bengaluru. Few other popular capsicum varieties such as Green Gold, Bharath.are also popular varieties among the growers. Special features of important varieties are as follows.

Soil

It can be cultivated in wide range of soils but sandy loam with a pH o 5.5 to 6.8 is ideal. Well drained loamy soil rich in organic matter is compartivlely better growing condition for capsicums. Water stagnation is detrimental to this crop. High acid soils need to be reclaimed using wither dolomite or lime stone before growing capsicums.

Season of sowing: September - February

Seed rate

For varieties: 1.25 kg/ha

For hybrids: 200 g / ha

Nursery: 3 cents /ha

Seeds have to be treated with of Carbendazim @ 2 g /kg of seed and sown in lines across the bed at a spacing of 2.5 cm and then cover with top soil and then paddy straw. Watering with rose can has to be done daily. On 20th day of sowing, 300g of carbofuran 3G granules have to be applied in between the seedling lines across the bed, the soil has to be stirred and then the beds are irrigated.

Protected nursery

- Nursery preparation in an area of 3 cents with slanting slope of 2 % is necessary for the seedlings production to cover planting area of 1 ha.
- Nursery area has to be covered with 50 % shade net and sides also have to be covered with 40/50 mesh insect proof nylon net.
- Raised beds have to be formed with the size of 1 m width and convenient length and HDPV pipes have to be placed at 2m interval for further protection with polythene sheets during rainy months.
- Sterilized cocopeat @ 300 kg is to be mixed with 5 kg neem cake along with Azospirillum and phosphobacteria each @ 1 kg. Approximately 1.2 kg of cocopeat is required for filling one protray. About 238 protrays (98 cells) are required for the production of 23,324 seedlings, which are required for one hectare adopting a spacing of 90 x 60 x 60 cm in a paired row system.
- Treated seeds have to be sown in protrays @ 1 seed per cell.
- Seeds have to be covered with cocopeat and arrangements should to be made to keep the trays one above the other and it should be covered with a polythene sheet till germination starts.
- After 6 days, protrays with germinated seeds have to be placed individually on the raised beds inside the shade net.
- Watering can be done with rose-can every day and drenching with 19:19:19 @ 0.5% (5g/l) should be done at 18 days after sowing.

Preparation of field

Field should be thoroughly prepared to a fine tilth and ridges and furrows should be formed at 45 or 60 cm apart. Transplanting can be doneusing 40-45 days old seedlings at 30 cm spacing.

Irrigation

Irrigation can be done at weekly or 10 days interval depending upon the soil and climatic conditions.

Layout and planting for precision farming systems

- FYM @ 25 t / ha can be applied as basal dose before last ploughing.
- 2 kg/ha of Azospirillum and 2 kg/ha of Phosphobacteria by mixing with 20 kg of FYM can also be applied.
- 75 % total recommended dose of super phosphate i.e., 703 kg / ha can be applied as basal.
- Drip irrigation with main and sub main pipes have to installed and lateral tubes have to be placed at an interval of 1.5 m.
- Drippers in lateral tubes have to be placed at an interval of 60 cm and 50 cm spacing with 4 LPH and 3.5 LPH capacities respectively.
- Raised beds of 120 cm width at an interval of 30 cm have to be formed and the laterals are placed at the centre of the each bed.
- Before planting, the beds have to be made wet using drip system for 8-12 hrs.
- Then planting can be done at a spacing of 90 x 60 x 60 cm in the paired row system, using ropes marked at 60 cm spacing.
- Pendimethalin 1.0 kg a.i. /ha or Fluchloralin 1.0 kg a.i/ha as pre-emergence herbicide can be sprayed at 3rd day after planting.
- Gap filling has to be done at 7th day after transplanting.

Application of fertilizers

FYM 25 t/ha and NPK 40:60:30 kg /ha as basal and 40 kg N/ha each on 30, 60 and 90 days of planting as top dressing.

Fertigation schedule for capsicum F1 Hybrid

Recommended dose: 250:150:150 kg / ha

Weed control

On 30th day, hoeing and weeding has to be done once and the plants are earthed up.

Growth regulator

Spraying of 1.25 ppm Triacontanol (12.5 mg /10 l of water) on 20th, 40th, 60th and 80th day after transplanting can be done for better vegetative growth of the plants.

Spraying of NAA 10 ppm (10 mg/l of water) on 60 and 90 days after planting can be done for preventing flower drop and improving the fruit set.

Diseases

Powdery mildew - wettable sulphur @ 0.3%

CIB recommendation - Myclobutanil 10% WP @ 0.04% or azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC @ 1ml/l

Anthracnose - Mancozeb 2 g/l or azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC @ 0.1% or metiram 55% + pyraclostrobin 5% WG @ 0.3%

Die-back and fruit rot - Mancozeb @ 2 g /l

CIB recommendation - Difenoconazole 25% EC @ 0.05%

Nematodes and sucking pests: Carbofuran 3 G @10-12kg/ha at 15 days after transplanting, followed by dimethoate @ 1ml/lit at 25 days interval.

Harvest and yield

Harvesting of fully matured green fruits can be done before ripening.

Yield: 15 tonnes/ha in 150-160 days.

Table 1: Varieties of Capsicum and their characteristics

Arka Athulya • High yielding F1 hybrid with powdery mildew tolerance. • Plants are continuous in growth habit with dark green foliage. • Suitable for fresh green market and yields 45-50t/ ha in 140-150 days. • Fruits are firm, blocky with 3-4 lobes and medium large (100-120g). • Suitable for kharif & rabi season cultivation under open field conditions.	 
Arka Gaurav • Indeterminate plant habit with green foliage. • Thick fleshed, 3-4 lobed green blocky fruits. • Average fruit weight 130-150 g. Fruits erect which turn orange yellow on ripening. • Yield potential of 16 t/ha • Duration of 150 days	 
Arka Basant • Indeterminate plant habit with yellow green foliage. • Thick fleshed, 2-3 lobed conical fruits • Average fruit weight 50-80 g • Fruits erect, cream coloured, orange red on ripening. • Yield 16 t/ha • Duration 150 days	
Arka Mohini • Determinate plant habit with dark green foliage. • Thick fleshed, 3-4 lobed dark green blocky fruits. • Average fruit weight 180-200 gms fruits pendent, which turn red on ripening. • Yield potential of 20 t/ha duration of 160 days	 

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Epigenetics: Useful Tool in Plant's Gene Regulation

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The field of epigenetics encompasses the study of heritable changes in gene expression that occur without alterations to the DNA sequence itself [Jablonka et al. 2002]. Epigenetics emerged as a field of research in the mid-20th century and has since grown significantly. The term "epigenetics" was first introduced by developmental biologist Conrad Waddington in 1942 to describe the interactions between genes and their environment during the development of an organism. Waddington used the concept of an "epigenetic landscape" to depict how different environmental factors can influence gene expression and development [Waddington et al. 2014, Deichmann et al. 2016].

Epigenetic mechanisms gained further attention in the 1970s with the discovery of DNA methylation. Scientists found that the addition or removal of methyl groups from the DNA molecule can lead to changes in gene expression patterns without altering the underlying DNA sequence [Riggs et al. 1975] [Holliday et al. 1975]. This discovery sparked interest in understanding how environmental signals and developmental cues can influence gene activity through epigenetic modifications. Over the years, advancements in molecular biology techniques, such as high-throughput sequencing and genome-wide profiling, have allowed researchers to explore epigenetic modifications on a larger scale. They have uncovered complex mechanisms involving DNA methylation, histone modifications, and non-coding RNAs that can regulate gene expression and contribute to various biological processes. It has contributed significantly to our understanding of how environmental factors, such as nutrition, stress, toxins and drought, can impact gene expression and potentially influence disease susceptibility [Iwasaki et al. 2014]. By studying the epigenetic regulation of gene expression, researchers aim to unravel the mechanisms that govern development, precisely reprogram the plant's transcriptome and create a balance among various important agronomic traits.

Types of Epigenetic Regulations

The three primary epigenetic regulations are histone modification, DNA methylation, non-coding RNA and. These techniques influence gene transcription, which in turn affects gene expression, rather than altering the DNA sequence [Gayon et al. 2016].

Histone modification

Most frequently, the amino acids on the histone tails are acetylated, methylated, or phosphorylated to modify histones [Felsenfeld et al. 2014]. The strength of the connections between histones and DNA can change depending on the kind of alteration, changing how chromatin is structured. For instance, acetylation reduces the interaction of the histone tail with the DNA's negatively charged phosphate groups by removing the positive charge from the histone [Rothbart et al. 2014]. The chromatin opens up and is more readily accessible for gene transcription when the contact between the positive and negative charges is reduced.

Several posttranslational changes of histones include acetylation, methylation, phosphorylation, ubiquitination, and sumoylation. Various environmental influences have been shown to cause dynamic epigenetic changes, a crucial signal-induced transcription mechanism [Jiang et al. 2020].

DNA Methylation

One of the most explored epigenetic processes is DNA methylation [Ashapkin et al. 2020]. In plants, a class of enzymes known as DNA methyltransferases links a methyl group (-CH3) to cytosine in symmetric, CG and CHG; and asymmetric, CHH, contexts (where H is any nucleotide except G) [Maeji et al. 2018].

Noncoding RNA

According to size, regulatory RNA may be broadly categorised into two groups [Ponting et al. 2009]: long non-coding RNAs (lncRNAs) and short chain non-coding RNAs (siRNAs, miRNAs, and piRNA. Non-encoding RNAs have been implicated in epigenetic alteration in recent years, and several studies have demonstrated that they may affect gene and chromosomal expression to govern cell development [Amaral et al. 2008].

Roles of Epigenetics in Plants

Epigenetics plays a crucial role in how plants respond and adapt to environmental stressors. Environmental stressors such as drought, extreme temperatures, salinity, and pathogen attacks can have a detrimental effect on plant growth and survival. However, plants have evolved various mechanisms to cope with these stresses, and epigenetics is one of them.

Epigenetic Regulation in Plant Growth and Development

Throughout their lives, plants can develop new organs, which allows them to sustain growth while modifying their rate for flexibility to respond to environmental changes. In addition to chromosomal variety, epigenomics also contributes to the maintenance of plants' flexible growth and developmental patterns [Ahn et al. 2017]. Recent work has shown the important role of epigenetic mechanisms in the regulation of plant growth and reproduction, including DNA methylation, histone variations and modifications, nucleosome positioning, and small [Feng et al. 2010]. These genetic and epigenomic factors that direct cell modification fates from vegetative to reproductive phase transitions regulate plant growth and development stages [Barozai et al. 2018]. The widespread 5-methyl cytosine methylation observed in the genomes of higher plants serves the crucial role of protection against the activation and movement of transposable elements and expression control of certain developmental genes. Numerous additional eukaryotic creatures still exhibit DNA methylation, despite distinct differences in the methylation enzyme systems and roles [Zhang et al. 2010].

Epigenetic Memory and Transgenerational Inheritance

Transgenerational inheritance, explain that it refers to the transmission of epigenetic marks from one generation to the next. Research findings that suggest certain epigenetic modifications can be inherited and potentially influence the traits or behaviors of subsequent generations. The following generation of stressed plants could continue to reflect differences in the epigenetic control of gene expression brought on by exposure to environmental stress [Molinier et al. 2006]. These effects may even be transmitted to at least two seed generations in some cases [Cong et al. 2019].

Stress adaptation occurs when a plant experiences stress repeatedly and becomes better equipped to handle future stresses [Rahavi et al. 2011]. This idea has been expanded to encompass a variety of features of how plant stress memories are created, where the changed condition of the plant's stress response is passed on through mitosis or meiosis [Mirouze et al. 2011; Murgia et al. 2015]. The genetic mechanisms behind stress memory in plants as well as its potential consequences on agricultural yields, particularly in severe conditions, are of major interest. Increased genome methylation is linked to genome integrity and stress tolerance, according to a previous study on Arabidopsis thaliana and Scots pine (Pinus silestris) growing close to the Chernobyl reactor [Kovalchuk et al. 2003].

DNA methylation and histone modification have changed as a result of several stressors, demonstrating their significance in a universal function in stress memory. Noncoding RNAs with variable expression are one of the other possible stress memory mechanisms. Small noncoding RNA, dicer-like proteins 2 and 3 (DCL2 and DCL3), have been demonstrated to have a significant role in the formation of transgenerational stress memory in the presence of several stressors [Migicovsky et al. 2013].

Phenotypic plasticity

Under stress, DNA sequence differences are frequently linked to plant phenotypic variety. It has recently been demonstrated that epigenetic changes can influence phenotypes individually or collectively by regulating gene expression in response to stress (e.g., DDT, heavy metals, salt stress). Natural populations may act differently when their environmental conditions are altered. The stress response mechanisms in one plant may not be the same as those in another [Bruce et al. 2007]. Environmental factors continuously shape postembryonic plant development, resulting in a high level of phenotypic plasticity. Although plants cannot escape their surroundings, they adapt to the changing and unfavorable growth conditions. The control of gene expression patterns and epigenetic regulation work together to promote metastable changes in gene activity. All these factors help the plants to cope to the unpredictable environments [Pikaard et al. 2014].

Environmental factors such as heat and dryness, can cause DNA's coding, promoter, or transposon regions to become hypo- or hyper-methylated. Mechanisms of DNA methylation in the maize inbred line during heat stress During the seedling stage, B73 identified 325 differentially methylated genes.

Conclusion

Recent research findings have demonstrated that new stable phenotypes can be generated through epigenetic modifications in a few generations, contributing to the stability and survival of the plants in their natural habitat, even though the preexisting genetic variation in the populations can explain a portion of the plants' adaptation. Epigenetic regulation can result in dynamic alterations, such as the plant hypersensitivity reaction (HR), alterations in the chromatin structure, and an impact on the plant phenotype, all of which help native plants adapt to stress. Therefore, understanding how epigenetic factors contribute to phenotypic plasticity and heritable variation is crucial to comprehending how naturally occurring populations may adapt to changing environmental conditions, particularly in global climate change.

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Ganoderma: A Potent Medicinal Mushroom

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Ganoderma is the name of the fungus *Ganoderma lucidum* (Ling zhi or Reishi). It is the first ever mushroom known to be used for health benefits. It is also called Reishi mushroom or in Chinese *Ling zhi*. According to Chinese medicine, *Ganoderma lucidum* can penetrate into and work on the five key human organs for impairment of the heart, lung, liver, pancreas, and kidney. It is one of the most popular medicinal mushrooms in China, Japan, and United States. The cap, spores, and mycelium are all used medicinally. Reishi is a polypore mushroom, growing in damp, dark forests and the occasionally rotting log or tree stumps.

Commonly known as reishi mushroom, genoderma is the most alkaline food in the world. Its scientific name is *Ganoderma Lucidum* and it is species of red mushrooms. It has a documented history of over 200 years and is the most revered herb in traditional Chinese medicine. Ganoderma or reishi mushroom was earlier referred to as "Herb of Spiritual Potency" and the "Ten Thousand Year Mushroom". Wealthy people in ancient times used this wonder mushroom in the hope of obtaining immortality and calmness.

Now this wonder herb is called the "King of the Herbs". Ganoderma is believed to promote health and longevity. It has been long used in Chinese medicine for treating a number of diseases like body aches, cancer, and liver diseases. It is also prescribed for various psychiatric and neurological diseases.

The taste is sweet and the property is neutral, therefore it is suitable to be consumed by anyone. In the Chinese medical concepts, the essence of the Ling Zhi is able to penetrate the organs and its meridians to improve the conditions of the lung, heart, spleen, liver and kidney. This natural herb protects our immune system, and boosts immunity, prevents a wide range of sicknesses and promotes self-healing.

Constituents of *Ganoderma*

It includes an array of alkaloids, triterpine acids, ergosterols, fumaric acid, coumarins, lactone, mannitol, proteins and amino acids and many water-soluble polysaccharides.

Nutritional Value

Ganoderma contains a whopping 400 nutrients! The nutrients present in this amazing herb promote health and vitality. Some of the important nutrients are polysaccharides, antioxidants, adenosine, protein and alkaloids. It contains potassium, phosphorus, calcium, Vitamin A, C, E, D and B complex vitamins.

Parts Used

The whole mushroom top, with as little shaft as possible. The larger the mushroom the better.

Typical Preparations of *Ganoderma*

Different preparations are made using mushroom cap, spores, and the mycelium. A common dose is 1,800–2,400 mg capsule form per day.

- Tea: Tea decoction from the dried mushroom, which Chinese medicine usually call for 1-8 grams of dried mushroom per cup of tea.
- Liquid extract: Powdered mushroom sprinkled on food or in beverages.
- Encapsulated (non-standardized) product from whole mushroom tops.
- Capsules
- Tablets
- Tea bags
- Tea granules
- Tinctures

So what's so good about *Ganoderma*?

- It is non-toxic and can be taken daily without producing any side effects.
- When it is taken regularly, it can restore the body to its natural state, enabling all organs to function normally.
- Immune modulator - regulates and fine tunes the immune system.

Benefits of *Ganoderma*

Improves liver function

Ganoderma is primarily composed of complex carbohydrates called water-soluble polysaccharides, triterpeniods, proteins and amino acids. These water-soluble polysaccharides are the most active element, that have anti-tumour, immune modulating and blood pressure lowering effects. Another major active ingredient found in *Ganoderma* are triterpenes , called ganoderic acids. These ganoderic acids helps to alleviate common allergies by inhibiting histamine release, improve oxygen utilization and liver functions.

Effect on Tumor

Ganoderma lucidum can best regulate and activate the immune system. It prominently enhances the body immune function and increase self defense capability against tumor. It enhances the function of monocytic macrophage *via* activating synthesis of *interleukin H*. It also enhances blood synthesis capacity, particularly white blood cells level. Combining with the inhibitory effect on cancer cells provided by certain ingredients in Ganoderma lucidum, it becomes one of the most effective medicines for anti-tumor, prevent cancer, and supplement to cancer treatment.

Enhance our body's immune system

Regular consumption of *Ganoderma* can enhance our body's immune system and improve blood circulation, thus improving better health conditions. Generally, Reishi is recommended as an adaptogen, immune modulator, and a general tonic.

Effect on Cardiovascular

Ganoderma lucidum can effectively dilate coronary artery, increase coronary vessel blood flow, and improve circulation in cardiac muscle capillaries, thus increase the supply of oxygen and energy to cardiac muscle. Therefore it helps to protect the heart from shortage of blood supply, and it is ideal for both curing and preventing heart diseases like nausea. *Ganoderma lucidum* can obviously reduce the level of blood cholesterol, liporotein and triglycerides in hypertensive patients. It prevents the formation of arterial atheromatous patches. If patches are already formed, *Ganoderma lucidum* will reduce cholesterol in arterial wall and soften the blood vessel to avoid further damage. It also partially improves blood circulation, and inhibits platelet aggregation. All these effects contribute to preventing various kinds of stroke.

Aging Prevention

The polysaccharides and polypeptides found in *Ganoderma lucidum* can effectively delay aging by the following mechanisms.

- To enhance and regulate immune function: Such enhancement and regulation can effectively delay aging in adult and aged people. For the youngster, the immune system will be optimized to ensure healthy growth.
- To regulate metabolism and enhance synthesis of nucleic acids and proteins: Ganoderma lucidum enhances synthesis of nucleic acids and proteins in blood plasma, liver, and bone marrow, hence effectively prevent aging.
- Effect on Free Radicals: One cause of aging is the reduction of self-originated antioxidant or antioxidant-like material (such as SOD) in the

body. These antioxidants are essential for encountering damage to the body by free radicals. Ganoderma lucidum polysaccharides possess the properties that are very similar to SOD which can remove the free radicals and prevent its damage to the body by stopping over-oxidation of lipid. Such action protects the cells and delays their aging.

- Ganoderma lucidum polysaccharides prominently enhance DNA synthesis in cell nucleus, and increase the number of cell divisions, which results in delayed aging.

Neuralgia and insomnia:

Using this herb for nerves can also help you to improve sleep and appetite, enhance energy, improve memory, and regain vitality.

Treatment of Diabetes

The constitutes in *Ganoderma* that reduce blood glucose are *Ganoderma* B and C. The principle is by enhancing utilization of blood glucose by body tissues. It serves as a substitute to insulin to inhibit release of fatty acids. It thus improves symptoms in high blood glucose and high urine glucose patients.

Effect on Chronic Bronchitis & Bronchus Asthma

Ganoderma can stop coughing, clear sputum, and suppress asthma. It also relieves the symptoms of the related illnesses. Since, it can activate the immune system, it can prevent from flu, and thus above syndromes.

Effect on Beauty Care

Ganoderma has been named the "Medicine of Eternal Life". It is mainly contributed to the effect on skin protection, and delaying aging. It can retain and regulate the water in skin and thus can keep the skin elasticity, hydrated and smooth. It also inhibits the formation and deposition of melanin in skin. Today, the beauty care products made from *Ganoderma lucidum* are becoming the new stars in the industry. To add Ganoderma lucidum into the bath will not only keep the skin smooth and lustrous, but also prevent it from bacterial infection.

Antioxidant benefits

Regular use of *ganoderma* supplements may increase your levels of antioxidants, compounds thought to protect against disease and aging.

Weight Loss

It rapidly oxygenates your body and automatically adjusts your PH to a healthy balance at the cellular level.

Fibroids (uterine myomas)

Ganoderma keeps the uterine lining from making both basic fibroblast growth factor (bFGF), a chemical that promotes fibroid growth, and histamine, a chemical that causes inflammation.

Stress

Ganoderma can reduce emotional outbursts during long-term stress.

Prevents and fights cancer

Ganoderma stimulates the body's production of interleukin-2, which fights against several types of cancer, and it contains compounds called ganoderic acids, which act against liver cancer.

Side effects of *Ganoderma*

Large doses (2–9 g) of *Ganoderm*a taken regularly over the course of 3–6 months may result in Abnormal bleeding, Low blood pressure, Stomach upset, Liver damage and other side effects viz., allergic reactions can cause dizziness, dryness of the mouth, throat, headaches, mild irritation of the skin, which may manifest as skin redness and rashes.

Ganoderma Mushroom Benefits for Health

Heart Health

Researchers in China and Japan have found that the ganoderic acid present in ganoderma improves blood flow and lowers oxygen consumption in the heart muscle. It also lowers cholesterol and inhibits platelet clumping, which often leads to heart attack. Ganoderma prevents the buildup of plaque in the arteries. Plaque restricts blood flow by narrowing the passage within the arteries, resulting in atherosclerosis. A study has found that consuming ganoderma for 2 weeks can significantly lower blood pressure.

Anti-Allergic

Ganoderma extract can significantly inhibit different types of allergic reaction, including asthma and dermatitis. Tritpenes, a compound found in ganoderma provides anti-viral and anti-allergic effects. It inhibits the histamine release, making the herb potentially useful for allergies. Polysaccharides improve the ability of antibodies to fight bacteria and viruses that cause allergic reaction. Ganoderma is useful for treating allergies caused due to atopic shock, dermatitis, hay fever, hives, and food and drug allergies.

Healing the Liver

This potent herb protects the liver from damage caused due to physical and biological factors. It also treats alcohol induced fatty liver and cirrhosis. Ganoderma can help people in the early stages of alcoholic liver diseases especially those who have not experienced severe loss of liver function. It also helps patients suffering from hepatitis B and elevated liver enzymes. Hepatitis B is quite difficult to clear from the body and its recurrence after treatment is high. The powerful compounds present in ganoderma accelerate the clearance of drugs and chemicals stored in the liver. The antioxidants present in ganoderma combats the free radicals, promoting liver regeneration.

Detoxify the Body

Ganoderma eliminates the toxins accumulated in the body due to excess intake of medicines and junk food. It promotes the efficient synthesis of bile and fatty acids, promoting faster detoxification of the chemicals from the body. Moreover, it enhances the body's ability to take in more than 1.5 times oxygen. Ganoderma rapidly oxygenates the body and adjusts its pH value.

Cure for Kidney Disease

Kidney disease includes chronic nephritis, diabetic renal syndrome, and nephritis. It occurs due to high blood sugar and cholesterol levels in the body. Overloaded kidney prevents the blood from reaching the renal capillaries. This causes fatigue, urine retention and uremia. Ganoderma lowers proteinuria and cholesyerolemia, maintaining proper renal function.

Sound Sleep

Chinese herbalists have traditionally recommended Ganoderma for its sleep promoting properties. Regular usage of ganorderma can promote a slow wave of sleep.

Mental Health

In Japan, dried Ganoderma is recommended for the treatment of neuroses caused by environmental stress. A study also found that regular intake Ganoderma can help patients suffering from Alzheimer's disease. It provides a calming effect, which is neither a narcotic nor hypnotic.

Muscle Relaxant

Ganoderma has been used widely for its muscle relaxing and pain inhibiting properties. It is believed that the herb can also treat anorexia and debility following a chronic disease.

Immune System

Ganoderma is very useful in boosting the body's immune system. Reishi mushrooms not only stimulate the immune system, but also regulate it. It regulates metabolic balance and promotes a synthesis of nucleic acid in the body. Polysaccharides raise the levels of interferon in the body by promoting the release of protein from the white blood cells. These white blood cells assist in inhibiting the spread of diseases. Studies have shown that patients taking ganoderma show fewer side effects from chemotherapy and radiation. The post-operative recovery is also smoother.

Ageing

The polysaccharides in ganoderma promote nuclear DNA synthesis and increased cell division, delaying the onset of ageing. It also contributes to longer life spans. This wonder herb helps to manage some of the most life-threatening age conditions and autoimmune diseases like cancer and other neurodegenerative diseases.

Weight Loss

Oxygen is very essential for burning fat for fuel. High levels of oxygen boost the body's metabolism, leading to weight loss. It increases the rate at which the body provides blood to the oxygen, giving you extra energy. Increased energy levels help you to work out for longer, aiding weight loss

Antioxidants

Ganoderma is a potent source of antioxidants. It contains one of the highest sources of antioxidant found in herbs. Ganoderma Lucidum peptide is the most powerful antioxidant found in this herb. Other antioxidants include polysaccharide, polysaccharide peptide complex and phenolic components.

Cancer

Ganoderma is touted for its anti-cancer benefits. It strengthens the immunity and combats cancer cell proliferation. It stimulates the production of interleukin-2, which helps to fight several types of cancer. Ganoderic acid, a compound found in ganoderma, helps to fight liver cancer. It counteracts suppression by stimulating the creation of protein in the bone marrow. In a trial, 34 people with advanced stage cancer were given ganoderma three times a day for 12 weeks. The results showed a significant increase in the T-cells.

Lack of oxygen is one of the major causes of cancer. Cancer cells are known to thrive in oxygen-depleted environment. Conversely, cancer cells cannot thrive in an oxygen rich environment. Several laboratory studies have shown that ganoderma can prevent cancer metastasis. It inhibits the migration of cancer cells and angiogenesis. The extracts of ganoderma are used in pharmaceuticals to suppress cancer cell proliferation. Furthermore, combining ganoderma with green tea augments its power to retard the growth of cancer cells.

Infection

Ganoderma stimulates the maturity of immune cells called macrophages, which digest infectious bacteria. This further prevents the development of secondary infection. It is also active against yeast infection.

Stress

Ganoderma has been prescribed since centuries to people suffering from stress and anxiety. It can effectively reduce emotional outbursts during chronic stress and depression. Ancient Chinese monks used reishi mushroom to calm their minds for meditation.

Skin Health

Topical application of ganoderma can be very effective for healing skin wounds, eczema, psoriasis, bug bites, stings, and scrapes.

Urinary Tract Infection

Ganoderma can also provide relief from urinary tract infections. In a study, 88 people suffering from urinary tract infection were given ganoderma for 2 weeks. The researchers found that ganoderma was significantly superior to placebo in providing relief from urinary tract infection. It inhibits 5- alpha reductase, an enzyme that converts testosterone to Dihydrotestosterone. These 5 alpha reductases can lead to swollen prostate and the health problem that accompanies it. It also improves urine flow in men with mild to moderate urinary tract symptoms.

Inflammation

Ganoderma extract is very effective for decreasing post-herpetic pain, which occurs soon after the herpes lesions heal. A combination of ganoderma with San Mioa (a mixture of several Chinese herbs) may help reduce rheumatoid arthritis. It helps to reduce the swelling associated with rheumatoid arthritis. Ganoderma is also effective for stiff neck and arms.

Blood Sugar

Ganoderma also provides blood sugar lowering effect. It contains polysaccharides known as Ganoderans A, B and C, which provides hypoglycemic effect. It elevates plasma insulin levels to enhance peripheral tissue utilization and liver metabolism of glucose.

Radiation

Ganoderma augments the effects of radiation therapy while acting directly against tumors. It strengthens the immune system, which helps the body to manage radiation therapy and chemotherapy. It also eases the symptoms of radiation therapy like nausea, vomiting, fever, infection, and hair fall and weight loss.

Dosage

Natural products are not completely safe. A specified dose is very important to make the most of these herbs. Ganoderma is available in capsule and tincture form in most health stores. You can take ganoderma in tea and coffee also. However, the addition of ganoderma to the tea and coffee can make them very bitter.

The dosage of ganoderma depends on several factors like age, health and several other conditions. 2.6 grams of concentrated ganoderma mushroom extracts can be taken with meals three times a day. For adults suffering from cancer, chronic hepatitis and diabetes, doses of 600 to 1800 milligrams should be taken daily. For high blood pressure, 55 milligrams of ganoderma is recommended. For the treatment of proteinuria (protein in the urine), 100 grams of ganoderma boiled in 300 ml of water is recommended.

Do not forget to consult your doctor before going ahead with the treatment.

Side Effects

- Some people might experience dry throat and nose, nose bleeding and gastrointestinal problems when consuming genoderma. Other side effects include bloody stools and itchiness in the nasal area.
- Some users may also experience constipation and diarrhea. Constipation may disappear within a few days of consumption.
- Do not take ganoderma if you are suffering from autoimmune diseases.
- Pregnant and lactating women should avoid taking ganoderma. Do not take ganoderma before or after surgery or childbirth.
- There is a possibility that ganoderma can make low blood pressure worse and can even interfere with the medications. Individuals suffering from this disease should consult their doctor before consuming this herb.
- High doses of ganoderma can increase the bleeding in people suffering from thrombocytopenia. Ganoderma contains adenosine, a substance that prevents the blood platelets from sticking together and forming clots.
- It may also lead to gastric bleeding in people suffering from stomach ulcers. Refrain from taking this herb until the ulcer heals.
- Dizziness is another possible side effect of reishi mushroom. It is often caused due to low blood pressure. It may also cause light-headedness and fainting spells.
- Ganoderma is known to cause breathing problems. Nasal discomfort along with difficulty in breathing and chest pain are common. These problems are usually caused due to allergic reactions. Get immediate medical help if you face any of these allergic reactions.
- Itching is another common side effect of this herb. It can lead to rashes all over the body. Itching is commonly accompanied by body aches and pain.
- Excess consumption of ganoderma can also lead to acne breakouts.

Fortunately, most of these side effects are temporary and subside with time. With right medical supervision, you can reduce these adverse reactions.

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Azolla Culture in an Aquaponics Unit

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Azolla (mosquito fern, duckweed fern, fairy moss, water fern) is a aquatic ferns in the family Salviniaceae. Azolla the Super plant that contents 4-5 times more protein than hybrid napier. It is a heterosporous aquatic fern distributed all around the world. Freely floating on the water surface. It can be used in animal and poultry feed as a protein source.

The genus *Azolla* was established by the French naturalist Jean-Bapitiste Lamarck in 1783 based on the specimens collected by Philibert Commerson and his assistant Jeanne Baré from the Magellan region of South America during Louis-Antoine de Bourgainville's1766-1769 expedition around the world:

Azolla is sometimes called 'small duckweed', but this is a misleading name. Azolla is a pteridophyte, whereas duckweed (also known as 'water lens' or 'bayroot') is an aquatic angiosperm (flowering plant) of the family Lemnoideae which has five genera: *Spirodela*, *Landoltia*, *Lemna*, *Wolffiella* and *Wolff ia*. Unlike azolla, duckweed does not contain endosymbiotic cyanobacteria. Azolla and duckweed are often found growing together in freshwater ponds, lakes and other bodies of still or sluggish water.

Types of Azolla

There are six species of Azolla – Azolla Carolina, Azolla nilotica, Azolla filiculoids, Azolla Mexicana, Azolla microphylla and Azolla pinnata. The *Azolla Pinnata* is a common species in India. But *Azolla microphylla* is a suitable species for quick biomass production under tropical and sub-tropical climate condition. The most common species of Azolla in India is Azolla pinnata. It produces more than 4 to 5 times of protein of excellent quality in comparison to lucern and hybrid napier.

Characters of Azolla

Azolla is a aquatic ferns characterized by its small floating sporophyte, which consists of a profusely branched stem bearing alternately arranged imbricate leaves and pendulous roots The leaves are two-lobed: one floating dorsal lobe and one submerged ventral lobe. It must grow in water or wet mud, and it dies within a few hours under dry conditions. Azolla can survive a water pH range of 3.5–10, but optimum growth occurs when the water is between pH 4.5 and 7. The optimum temperature for azolla is between 64 and 82°F (18–28°C).

Azolla hybrids

Hybrids are commonly produced and selected because they have desirable characteristics not found or inconsistently present in the parent individuals or populations. Azolla hybrids have been developed to improve the plant's temperature tolerance and biomass production. For example, hybridization between *A. microphylla* and *A. filiculoides* improves annual biomass production, as illustrated by a study by Van Cat *et al.* (1989). In the parent material, the latter grows better in the spring, while the former grows better in the summer and autumn due to its higher-temperature tolerance. The hybrid, however, produced biomass comparable to that of *A. filiculoides* in the spring and comparable to that of *A. microphylla* in the summer and autumn, thus boosting overall annual production.

Van Cat *et al.* (1989) showed that the hybrid did not show stress (characterized by a red color) under phosphorus- or calcium-deficient conditions and that the hybrid had a higher nitrogen content than the parent *A. microphylla*. Biomass production in the field was also higher in the hybrid than that of *A. microphylla.*

Azolla Cultivation Procedure

Slurry made of 2 kg cow dung and 30 g of Super Phosphate mixed in 10 litres of water, is poured onto the sheet. More water is poured on to raise the water level to about 10 cm. To cover the 6 feet X 4 feet pond, 1 kg of fresh Azolla culture is required. Apply this culture uniformly in the pond. Make sure to have the water depth at least 5 to 6 inches in the pond. This will grow rapidly and fill the pit within 10 – 15 days.

Advantages of Azolla

- It can easily be produced in large quantity required as green manure in both the seasons – Kharif and Rabi.
- It can fix atmospheric CO2 and nitrogen
- It solubilises Zn, Fe and Mn and make them available to the rice.
- Azolla can be a substitute for chemical nitrogenous fertilizers to a certain
- Azolla helps in weed control and suppresses tender weeds such as Chara and Nitella in rice field.
- In natural way, Azolla releases plant growth regulators and vitamins which are very much required to enhance the growth of paddy crop.
- Azolla helps increase the crop yield and quality. It also plays a great role in functioning as a green manure in order to maintain the fertility of the soil.
- It acts as a renewable biofertilizer not only in paddy fields for growing the productivity of certain crops but also helps to influence soil fertility by decomposing itself rapidly and its nutrients are released in the water to enrich the soil as well as the field suitable for the next crop.
- the role of azolla in livestock production and described the feeding of azolla to dairy cows increased milk production by 15 to 20% and also improved the weight of broiler without any adverse effects.
- Around 10 q of Azolla is required for a hectare of land.

Nutrition value in Azolla

Azolla is very rich in protein (25-35%), Calcium (67 mg/100g) and Iron (7.3 mg/100g). The comparative analysis of the nutrient content of azolla vis-à-vis other fodder source is depicted in the table 1.

Limitations of Azolla Culture

Huge quantity of inoculums is required which is difficult for transplanting action during rainy days. Temperature more than 35°C is not suitable. Extreme low temperature is also not suitable. Non availability of technology to use Azolla as dry inoculum.

Precaution to be adopted in azolla cultivation

- A shady place, preferably under a tree, with sufficient sunlight should be chosen for the Azolla production unit.
- A place of direct sunlight should be avoided.
- All corners of the pit should be of the same level so that the water level can be maintained uniformly
- pH of the medium should be between 5.5 to 7.
- Suitable nutrients such as cow dung slurry, micronutrients should be supplemented as and when required. The gradual decrease of the growth rate in the pond water was mainly due to phosphorus deficiency.
- Temperature is an important factor for good growth. It should be around 35 degrees Celsius.
- Maintenance of pure culture is essential for good yield.
- Azolla should be harvested regularly to avoid overcrowding.

Table 1: Comparison of biomass and protein content of Azolla with other fodder

S. No.	Item	Annual production of biomass (MT/ha)	Dry matter content (MT/ha)	Protein content (%)
1	Hybrid Napier	250	50	4
2	Kolakattao grass	40	8	0.8
3	Lucerne	80	16	3.2
4	Cowpea	35	7	1.4
5	Subabul	80	16	3.2
6	Sorghum	40	3.2	0.6
7	**Azolla**	**1,000**	**80**	**24**

Source: Dr P Kamalasanan et al. 2004 "Azolla -A sustainable feed substitute for livestock", Spice India.

Nano Technological Approaches in Horticulture

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In order to increase crop output and ensure the food security of the world's growing population, plant nutrition is essential. Pesticide and chemical fertilizer applications are the foundation of any agricultural economy. Nanotechnology is the most recent advancements for sustainable agriculture. The use of nanotechnology in horticulture and agriculture is currently very common. The factor affecting fruit trees that has been the subject of the most research and development is nano fertilizers (NFs), which are crucial for enhancing vegetative growth, reproductive growth, and flowering, which increases productivity, improves product quality, and ultimately lengthens shelf life and reduces fruit waste. These nanomaterials that are often sprayed on trees at low concentrations over a period of time and in multiple sessions are also regarded as growth promoters. Because nanoparticles have unique physicochemical properties, such as a large surface area, high reactivity, and tuneable pore size, nanotechnology opens up a wide range of innovative uses in the plant nutrition disciplines to meet future demands of the growing population (Pandey et al., 2021).

Applications of nanotechnology in horticulture

According to Singh and Ratanpal (2014), the quantity of waste produced by horticultural products is projected to be between 20 and 30 percent in developing nations. If we can cut this number by just 5 to 10%, enormous savings will be realised. In a location wherein per capita consumption is just half of the recommended level, reducing these losses could both increase farmer incomes and stimulate higher consumption of this very nutritious fruit. The best way to solve this issue is to use cutting-edge technologies like biotechnology and nanotechnology in products to improve production efficiency and reduce post-harvest waste. The management of supply chain operations related to the quality of food, handling, packaging, and safety has already benefited from the use of nanotechnology. Through improvements in agri-food production, processing, preservation, and packaging, the application of nanotechnology in the field of agricultural supply chains is already delivering potential benefits to farmers, the food business, and consumers alike (FAO/ WHO, 2010)

Role nanomaterials on growth and development of horticultural Crops

Solid colloidal particles known as nanoparticles are made up of macromolecular substances. The use of nano fertilizers, which promote extremely effective plant nutrition and are environmentally friendly, increases agricultural output. Nano fertilizers are given to the plants gradually, precisely, and effectively. For instance, according to Prasad et al. (2012), ZnO nanoparticles increase the yield of peanuts (Arachis hypogaea). Nano fertilizers are used in horticulture to boost flower fertility, pollination, and vegetative growth, which increases fruit tree productivity and improves product quality (Zagzog et al. 2017). Similar to this, spraying nano-boron on mango tree leaves has been shown to increase overall yield and chemical characteristics of fruits (Abdelaziz et al. 2019). This positive effect is thought to be related to the enhancement of chlorophyll content and essential nutrient elements such as nitrogen, phosphorus, potassium, (K), manganese (Mn), magnesium, boron (B), zinc (Zn), and iron (Fe) in the leaves. According to Zagzog et al. (2017), spraying mango trees with nano-zinc increases fruit weight, fruit number as well as yield, leaf chlorophyll and carotene levels, and concentrations of numerous nutrient components including N, P, K, and Zn. Similar to this, applying fertilizers containing nano-boron and nano-zinc enhances fruit quality, yields more fruits, and raises total sugar and total phenol content in pomegranates as well as the ratio of total soluble sugars (TSS) to maturity index (Davarpana, 2016).

Nano fertilizer

The process of creating nano fertilizers involves combining plant nutrients with nanomaterials, coating nutrient molecules with a thin layer of nanomaterials, and creating emulsions that are only a few nanometers in size. When compared to conventional fertilizers, nano fertilizers and nano biofertilizers, which contain both natural and synthetic components, wisely boost soil fertility and bioavailability. However, the three most crucial properties of nano fertilizers are (i) a bulk size of about 100 nm; (ii) a particle size of less than 100 nm; and (iii) the nanoproduct must be durable and safe for the environment. Retaining its nanosize and aggregates when interacting with soil particles or agricultural plant roots is another characteristic of a nano fertilizer.

Enhancement of Shelf-Life of Horticultural Crops by Nanomaterials

There are a number of conventional preservation methods; however, they are all costly, ineffective at extending shelf life, or constrained by an unfavourable residue. The employment of shelf-life expansion strategies based on nanotechnology has the potential to minimise the limitations of traditional methods due to a number of regulatory properties of nanomaterials.

Nanofilms/Coatings

Metal nanoparticles (NPs) are transported by nanofilms, which act as protective barriers and antimicrobials. These cutting-edge materials reduce the rate of respiration, control colour change and breakdown, balance storage conditions, and extend the shelf life of horticulture crops. It is suggested that using edible nanofilms is a practical technique to maintain the qualities of horticulture goods during storage and shelf-life. Recently, Dubey et al. (2019) produced a nano-composite edible film made of glycerol, aloevera gel, and ZnO-NPs solutions.

Nano packaging

Nowadays, it is recognized that nano-based technologies are the most efficient in food processing and packaging. Foods with high quality and long shelf lives can be enhanced and preserved with the use of nanoparticles in nano wrapping and processing techniques. Metal nanoparticles as Ag, Cu, TiO2, and MgO (Islam et al., 2018), edible antibacterial nano-composite films, and gas scavengers (Lee et al., 2015) are examples of active food nano-packaging materials. For instance, by absorbing ethylene gas, the addition of Ag-NPs nanoparticles extended the shelf life of fruits and vegetables (Hu and Fu, 2015). It was discovered that when food is packaged and processed, nanocrystalline TiO2 acts as an oxygen scavenger (Kuswandi, 2107). Food material shelf life can be increased by Ag-NPs coated packaging materials by reducing microbial activity (Sidorowicz et al., 2021).

Nano sensors in Precision Horticulture

According to Scoville (2018), a nano sensor is any instrument that has the ability to transmit information and proof about the actions and traits of NPs at the nanoscale level to the macro level. Real-time monitoring of fields crop, crop development, and disease and pest incidence requires nano sensors. Metal nanotubes, nanowires, nanofibers, nanocomposites, nanorods, nanostructured polymers, and various allotropes of carbon, such as carbon nanotubes, graphene, and fullerenes, are nanosized materials that can be utilised for sensor fabrication (Márquez and Morant, 2015). With real-time monitoring, agricultural production can use less pesticides and fertilizers than necessary, lowering both production costs and environmental degradation.

Conclusion

Modern agriculture is using nanotechnology as a cutting-edge tool to support sustainable agricultural production. It also holds enormous potential for horticulture, as various nanomaterials are employed to boost production, improve the quality of products, and lower fruit and vegetable rotting after harvest. The power of nanoparticles and their techniques of dispersion are leveraged by nanotechnology to increase crop productivity in the horticultural sector.

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Table1. Influence of nanoparticles (NPs) on germination, growth, development and yield

Nanoparticles	Dose (mg/L)	Crop	Effect on Plant Growth and Development	Reference
TiO2	1000 to 2000	Spinach	Promotes growth and photosynthesis.	Hong et al. 2005
Carbon nanotubes (MWCNT)	10–40	Tomato	Enhances germination and growth rate but inhibits elongation of root in tomato.	Khodakovskaya et al. 2013
Fe3O4	0.67	Lettuce, spinach, radish, cucumber, tomato, peppers	Inhibits seed germination	Torre-Roche et al. 2013
ZnO	100-1000	Garden pea	No effect on seed germination but affects nodulation and root length	Raliya et al. 2015
Carbon nanotubes (MWCNT)	10–40	Onion and cucumber	Enhances elongation of root	Canas et al. 2008

Table 2. Effects of nano components on different horticultural crops

Nanofilm/Coating Component	Beneficial Effect on Fruit	Fruits	References
Chitosan	delays the aging process, water loss, and fruit firmness	Mango	Silva et al., 2017
Chitosan	Improves stiffness, slows down the pace of weight loss, and increases the antioxidant process.	Guava	Silva et al., 2018
Chitosan-carboxymethyl cellulose/Mentha spicata essential oi	The antibacterial properties of the coating work well. Favourably affects respiration rate, pH, water vapour resistance, weight loss, and titratable acidity.	Strawberries	Shahbazi, 2018
Nano-ZnO	Six extra days can be added to the shelf life of fresh-cut apples with nano-packaging.	Apple	Li et al., 2011

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Traditional Beekeeping: A Time-Honoured Craft

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In an era of swift technological progress and constantly shifting fashions, there is a classic craft that hasn't altered much in hundreds of years: traditional beekeeping. This age-old practice, rooted in the symbiotic relationship between humans and honeybees, stands as a testament to the profound wisdom of our ancestors. The building of beehives and the meticulous care of the bees are the two main components of this craft and the construction of beehives, has evolved over generations to accommodate both the needs of the bees and the beekeepers (Grenier, 1998). Traditional beekeeping, which has been passed down through the ages, is more than just the skill of extracting honey; it is a way of life, a connection to nature, and a significant component of cultural legacy. The article dives into the fascinating world of traditional beekeeping, examining both its ecological importance and its rich history. Furthermore, it will unravel the diversity of beehive designs and structures utilized in this ancient craft, demonstrating the intricate and creative ways that people have interacted with these magnificent creatures.

History of Traditional Beekeeping

The roots of traditional beekeeping reach far into history, dating back thousands of years. The earliest evidence of beekeeping can be traced to ancient Egypt, where clay pots adorned with hieroglyphs depict scenes of honey collection. The practice is also mentioned in ancient texts, such as the Vedic scriptures of India and the writings of Aristotle. These historical records provide a glimpse into a world where the relationship between humans and honeybees was not solely about resource extraction but rather a harmonious coexistence. As time progressed, beekeeping techniques and hive designs evolved. Ancient Greeks and Romans are credited with developing the log hive, a simple yet effective structure that provided shelter for bees. Medieval Europe saw the emergence of skeps, woven from straw, and cylindrical hives. Over time, the craft spread to various corners of the world, each region adding its own unique twist to beekeeping traditions. This historical tapestry of beekeeping traditions serves as a testament to the adaptability and innovation of human culture.

Significance of traditional beekeeping

Ecological Significance

Beyond the sweetness of honey, traditional beekeeping plays a vital role in maintaining ecological balance. Bees, as pollinators, are essential to the reproduction of countless plant species, including many of our food crops. This ecological interdependence ensures the abundance of fruits, vegetables, and flowers while safeguarding the habitats of various wildlife species. However, in recent years, there has been a growing concern about the decline in bee populations worldwide due to factors such as pesticide use, habitat loss, and climate change. In this context, traditional beekeeping emerges as a guardian of bee populations and biodiversity.

Cultural Relevance

Traditional beekeeping is not only a practical endeavor but also a cultural touchstone in many societies. It is a practice that bridges generations, connecting the past with the present and the future. In different regions and cultures, beekeeping carries unique traditions and rituals, often entwined with folklore and storytelling. The bee, with its industrious nature and cooperative hive structure, is a symbol of community, dedication, and harmony in many cultural narratives. In some communities, beekeeping is not only a source of sustenance but also a sacred tradition. The maintenance of these traditions becomes a point of pride, uniting communities in the shared knowledge and practice of beekeeping.

Health Benefits

Honey from stinged and stingless bees is considered as an energy-rich medicinal product. Generally, it is obtained from the species *Apis dorsata, A. florea, A. cerana* and Italian bee, *A. mellifera*. Since, *A. dorsata* is a wild rock bee and it can't be domesticated, the beekeepers rear *Apis cerana* and *Apis* *mellifera*. Tribal peoples living in the Himalayan mountains and Western Ghats are successfully rearing Indian bees and stingless bees which are somewhat difficult to be reared in the popular modern bee hives. The medicinal honey from *A. cerana* and stingless bees represents the high nutritional and therapeutic properties of indigenous honey.

Traditional Beekeeping with different types of bee hives

The native bee, *Apis cerana* is known to better survive winter in wall hives compared to freestanding hives or wild colonies. In mountainous regions and hilly terrains of India (Verma and Attri, 2008; Singh, 2014) such as Himachal Pradesh, Jammu & Kashmir, Uttarakhand, and Uttar Pradesh etc farmers have traditionally managed the indigenous honey bee *Apis cerana* in log and wall hives close to their homesteads which are a form of traditional fixed comb hives. In Kullu (Sharma et al., 1998), Chamba (Verma & Attri, 2008; Sharma et al., 2022), Sirmour (Kumar and Thakur, 2016) and Kinnaur (Bhatia 1999, Rafal 2000) and other hilly areas of Himachal Pradesh, people keep *A. cerana* in both traditional and movable frame bee hives- Log hives and wall hives. The tribal people of the Western Ghats are also successfully rearing stingless bees, which are small and resident species that nests among boulders, old walls, dead trees and tree cavities. The different types of bee hives used in traditional beekeeping are shown in Figure 1.

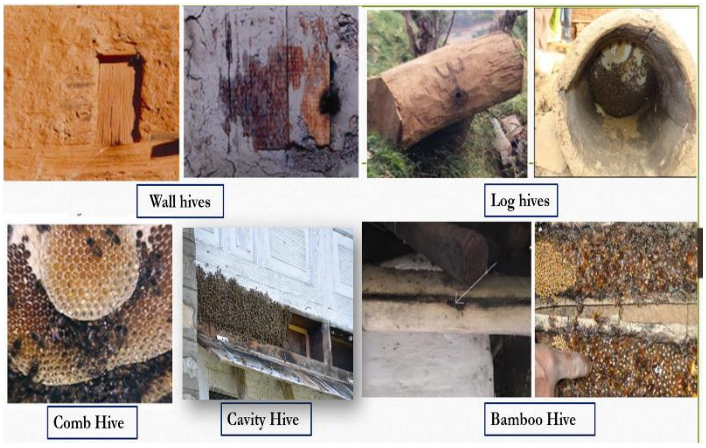

Figure 1. Different types of traditional hives used by tribal people of from regions of Himalayan mountains and western Ghats

(Source: Verma and Attri, 2008; Sharma et al. 2014; Sood, 2022; Kumar et al. 2012)

Low-cost mud hives- A way towards conservation of *A. cerana*

A new technology in the form of low-cost mud hives for rearing the indigenous honeybee, *A. cerana* is a way out for their conservation which has been brought out by Dr. J P Sharma, during 2007-2008 in Himachal Pradesh. Fixed bee hive, so named because it is fixed in one place and cannot be shifted from one place to other as can be done with Bureau of Indian Standard (BIS) wooden beehives. This mud hive has the qualities of both modern and traditional hives.

Merits of Traditional Beekeeping

Traditional beekeeping besides promoting biodiversity, supports ecosystem, providing high nutritional as well as therapeutic properties of indigenous honey and preserving culturing heritage along with sustainable traditions. The traditional bee hives are made with locally available materials or using wall spaces in the dwellings which are safer from wild animals and maintain a suitable

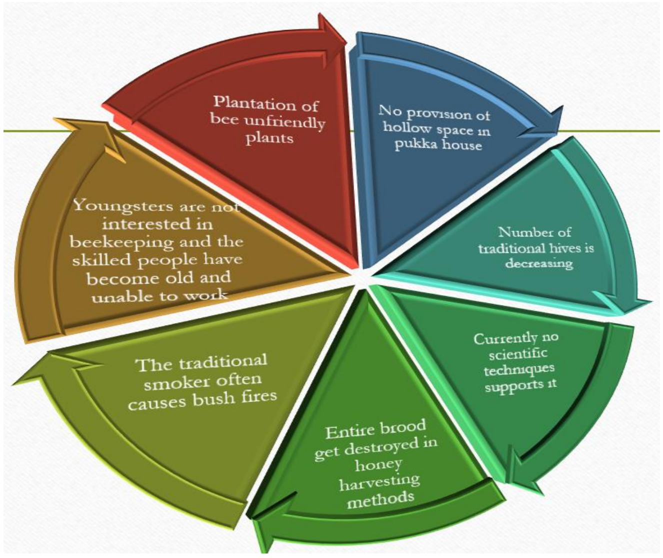

Figure 2. Constraints and challenges to traditional beekeeping

temperature. The designs of the hives are very simple, the only consideration is the volume of the bee cluster to be accommodated. There is no input in the form of sugar feeding, comb foundation, chemicals etc. The management of colonies is minimal and consists of arrangements for the attraction of swarms and harvesting of honey. Traditional beekeeping integrates itself with the prevailing customs and socio-economic conditions of the people and helps conserve the biodiversity in bee fauna. Besides, so many benefits, the constraints and challenges to traditional beekeeping are shown in Figure 2.

Conclusion

Traditional beekeeping is a live heritage of hilly terrains, tribes and some incredible techniques beyond envisage, because they have learned by practice since immemorial or by themselves. Tribals and residents of steep terrain have been caring for A. cerana bees in a particular method for ages that they inherited from their dads and ancestors. These indigenous hives still have significant potential as compared to contemporary beekeeping because of their low cost and appealing management techniques. Indigenous beekeeping blends nicely with the community's socioeconomic structure and established practices. Since small-scale traditional beekeeping has the benefit of cheap input costs in the context of bee hives and is safer against natural enemies, training and supporting these beekeepers may result in better success in the apiculture market.

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Digital Twins: An Emerging Tool for Food Process and Product Design

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The continuous automation of conventional manufacturing and industrial procedures utilizing cutting-edge smart technologies is known as the Fourth Industrial Revolution, or Industry 4.0. Knowledge management, big data analysis, cyber-security, cyber-physical systems, robotics, computer vision, human-computer interface, and simulation are some of the components that make up the technology. Faster algorithms, more computing power, and a wealth of available data enable the modeling of real-time control and optimization of goods and production lines, thanks to the Industry 4.0 vision and the growth of big data analytics. One of the key components of the fourth industrial revolution is the digital twin (DT), or digital representation of the physical model. It is anticipated to make it possible to predict future system performance accurately and to effectively maintain process quality by facilitating simple visualization and the integration of cognitive capabilities into the actual system (Bottani *et al.*, 2020).

A digital twin of a certain product is defined as a virtual representation of its real-world counterpart, which contains all essential elements, such as all geometrical components and material properties; simulates accurately and realistically all relevant processes and their kinetics throughout the product's life-cycle; and is connected to the real-world product and processes by sensor data, which is preferably continuously updated in real-time (Shrivastava *et al.*, 2021). The digital twins can be classified either as a digital model, digital shadow or digital twin.

Elements of digital twin

Digital twins are there in various engineering fields and in health sector also. In order to successfully adopt the technology for food processing operations, the following elements are required.

Sensor

Sensors allow communication over wireless network, allowing to capture data, activation, programming and operation. The sensors selected are normally cheap, simple and wireless ones that exploit different parts of electromagnetic spectrum such as Nuclear magnetic resonance and other spectroscopic imaging techniques for measuring temperature, humidity, gases, light,stress, flow rate and pressure.

1) ***Big data***

Data from the sensors are integrated and combined with data from enterprise and are communicated to digital world through integration technologies. Statistical data analysis tools including statistical process control (SPC), multivariate statistics (MVS), data mining (DM), machine learning (ML) and deep learning (DL) are used for analysis of big data and will be provided by operators including Amazon, Microsoft, IBM, GE and SAS.

Physics based model

They rely on CAD geometries of the product, material property data and initial and final boundary conditions. They require an appropriate mathematical formulation of the relevant underlying biological processes that affect quality attributes, such as biochemical reactions involved in the respiration metabolism. Physics-based models do not suffer from statistical uncertainty or biological variability in the data. Discrete event simulation (DES) is a popular tool for modelling multi product batch plants and include ProModel from ProModel Corporation, Arena and Witness from Rockwell Automation, and Simio from Simio LLC. Mathematical optimization tools include SAP APO from SAP AG (Walldorf, Germany), IBM ILOG Plant PowerOps from IBM Corporation (Armonk, NY, USA), Aspen Plant Scheduler from Aspen Technology (Burlington, MA, USA) etc…

Actuators

Should an action be warranted in the real world, the digital twin produces the action by way of actuators, subject to human intervention, which trigger the physical process.

Creating a digital twin

The creation of digital twin and getting started with a digital twin can be best understood in terms of 6 steps as follows:

1) **Create:** This step encompasses outfitting the physical process with sensor that measure critical inputs from the process and surroundings. The sensor can measure either the (a) operational parameters such as tensile strength, displacement, strength and color uniformity or (b) environmental data affecting the performance including temperature, pressure and humidity level.
2) **Communicate:** This step help in real time seamless bi-directional connectivity between the physical system and digital platform. Network communication comprises of three primary components:
   - Edge processing: The edge interface process signals and data from sensor and pass it along the digital platform.
   - Communication interface: This helps in transferring information from sensor function to integration function.
   - Edge security: New data communication techniques have developed data security issues also. The common security approaches are to use firewalls, encryptions, application keys and device certificates.
3) **Aggregate:** This step supports ingestion of data to suitable data repository.
4) **Analyze:** The data is analyzed and visualized in advanced analytic platforms.
5) **Insight:** In this step, insights from analytic step are presented through dashboards, highlighting the difference in operation between physical system and digital part and thereby indicating areas that need immediate investigation and change.
6) **Act:** In this step, actionable insights from the previous step is fed back to physical system thereby creating an impact of digital twin in physical system.

Digital twins in Product and Process Design

Digital twin to develop pasteurization system for beverages

Digital twin models are used to replicate pasteurization process of food beverages. Bottani *et al*., 2020 developed a digital twin for a pasteurization system of food beverages. The pilot plant consisted of a pulsed electric field for sterilization, a preheating system of tube in tube heat exchanger and an electric steam generator. The digital twin system consists of a simulation tool developed under LABVIEW, cloud server system to communicate with HMI (human machine interface) and user device and an anomaly prediction tool. Each variation in the controlled parameter correspond to analogous variation in system. Anomaly prediction tool analyses status of line in real time and adjust parameter thereby acting on real system by feedback control mechanism.

Digital twin to identify trade-off between drying time

The digital twins can monitor trade-off between drying time and quality during drying process. Praviranto *et al*., 2021 proposed a model that was able to predict drying time thereby preventing over drying or under drying, provide information on drying state of product and having all elements to capture relevant heat and mass transfer kinetics and quality degradation. The study was conducted in four different variations where the basic configuration was a simple solar dryer consisting of collector, glass cover, air channel, absorber plate and insulator. The second configuration incorporated a storage bed made of sand, third configuration had a dehumidifier unit and the fourth unit had an air heater to heat up the incoming air. The digital twin model first needed to be fed with weather data in order to assess variation in drying time and final quality of product. The information on dehydration state of product helps the operator to decide when to stop drying. Simulations are performed using finite element method in COSMOL Multiphysics version.

Digital twins to assess performance of e-gastronomic things

Karadeniz *et al*., 2019 proposed a digital twin model for an ice-cream machine. Gastronomy includes the process of cooking, serving, presenting and preparing food and the digital cloning of gastronomic things comes under e-gastronomy. The physical entity consisted of sensors to measure temperature, hardness, hopper condition and operation of valves.

The digital twin model was able to be accessed by the end users and technicians via virtual reality and augmented reality respectively. Virtual manual enables training to end users and technical staff to fix problems. Virtual reality explains step by step for end user indicating current status of physical pair in digital world. Augmented reality is for technicians thereby presenting instant data.

Digital twins in oil extraction perspective

Andrade *et al*., 2020 developed a digital twin model for essential oil extraction plant. The physical is a steam distillation unit. The distiller is of 10kg capacity. Before starting the process, bottom portion of distiller is filled with water. Electrical heating element is immersed in the water. Level switch make sure the amount of water. The water turns to steam and passthrough distiller. Temperature sensors are provided in the top, middle and bottom parts of distiller to prevent channelling. Flow indicator near condenser measure essential oil and hydrosol reaching the condenser. The essential oil tube is monitored by image processing done by Raspberry pi model and camera module v2. Algorithm prepared in OpenCV in python. The algorithm explains color detection and finding contours. The digital twin model is created in MATLAB which increases yield. Mathematical model is created in Simulink in MATLAB. The digital model is a hybrid model comprising of a physical model and a data driven model. The physical model is based on Fick's law for mass diffusion and Darcy's law for flow through porous media. Color of the oil, raw material present in distiller and information on undesirable change in process dynamics are given by digital twin.

Conclusion

Digital twins can combine the advancements in science together thereby providing an efficient way to monitor various operations and processes that are taking place in a food industry. For the success of a digital twin technology, food process modeler, specialists in sensor technology, ICT, programming, optimization, statistics and artificial intelligence need to work together. The success of implementing digital twin workflow with respect to ease of use and reliability, will determine whether digital twins will survive for food processing operations. The optimization capabilities, the possibility of saving resources, the production control and the data analysis are some of the reasons the digital twins must be more discussed, creating better solutions for the food industries.

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Biofortified maize for improved productivity and quality

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Maize, also known as queen of cereals, has been a staple food for centuries, providing sustenance to millions of people around the world. Together, the three main global staple grains - wheat, rice, maize - make up an important part of the human diet. Compared to wheat and rice, maize is a more versatile multi-purpose crop. It is a major food crop that is cultivated on a large scale for commercial purposes as well as for sustenance by numerous farmers who have little resources. It is not only food, feed and fodder crop but maize finds application in the production of biofuels, pharmaceuticals, and industrial materials also. It serves as a dietary staple in many regions, providing a rich source of carbohydrates, fibre, and essential nutrients. Since there are many types of maize like normal maize, baby corn, sweet corn and popcorn it can be used in different ways. Maize is not only consumed directly but is also a vital ingredient in numerous food products, including flatbread, baked bread, tortillas, cereals, and animal feed. Its production and consumption have significant economic and social implications for farmers and their communities. Earlier there was a gap for upliftment of maize because of the nutritional quality of maize. This nutrition gap was pronounced mainly for two essential amino acids- lysine and tryptophan. Normal maize has low content of essential amino acids and vitamins that is why the food or feed made from it is nutritionally poor and result in poor growth in animals and human being when it is consumed in the form of feed and food respectively. It also results in low milk productivity in cattles and meat productivity in poultry and swines.

With the development of biofortification in maize, a speciality maize known as Quality protein maize, has been developed that provides a new opportunity to use maize for food revolution. The quality protein maize (QPM) is a specialized maize which is similar to normal maize in appearance, grain yield, resistance to different biotic and abiotic stresses but it has double the content of lysine and tryptophan than the normal maize and has double biological value than the normal maize. Here are some noteworthy developments from Chaudhary Charan Singh Haryana Agricultural University with their average yields: HQPM 1 (*Kharif*- 57-62 q/ha, *Rabi*- 65-70 q/ha), HQPM 4 (*Kharif*-55-60 q/ha), HQPM 5 (*Kharif*- 60 - 65 q/ha, *Rabi* -67.5 - 72.5 q/ha) across the country and HQPM 7 with average yield 63 q/ha in Peninsular Zone of India. These hybrids possess high protein content (9.0 - 10.8 %) along with high tryptophan content 0.85-0.94 %) and lysine content (>2.5%). Efforts were also successful for the development of biofortified maize enriched in Provitamin A also by CCSHAU in collaboration with ICAR- Indian Agricultural Research Institute and named as interinstitutional hybrids.

Provitamin-A is the precursor of Vitamin A and the maize rich in Pro vitamin A has four times provitamin-A (4 ppm) as compared to normal maize (approximately 1ppm) after four months of storage of maize. The QPM hybrids which has additional trait of pro vitamin A may be helpful not only eradication of malnutrition problem in the country but helpful in earning foreign currency by exporting it directly as grain or by developing value added products. Some of the biofortified maize hybrids enriched with Provitamin A are: Pusa HQPM 1 Improved (Posseses high provitamin-A (7.02 ppm) high lysine (4.59%) and tryptophan (0.85%)), Pusa HQPM 5 Improved (Possesses high provitamin-A (6.77 ppm), high lysine (4.25%) and tryptophan (0.94%) and Pusa HQPM 7 Improved (Possesses high provitamin-A (7.10 ppm), high lysine (4.19%) and tryptophan (0.93%)).

Thus, with the embrace of these advancement in normal maize, it is not considered as an ordinary cereal, rather it is a nutria-cereal, a cereal grain being rich in nutrients and have numerous health benefits. It results in better growth in animals and human being when consumed in the form of feed and food respectively. More importantly, it is also rich in important vitamins and minerals such as vitamin C, vitamin B6, magnesium, folate and potassium like normal maize. A balanced life can be achieved if quality protein maize is included in our daily consumption and required to meet quality protein needs and raise the human nutritional status. Like all other foods, it should be consumed in proper amounts as a balanced diet as it provides antioxidants, fiber, proteins and more importantly it is gluten free. It is the boon for patients suffering from celiac disease- a disease in which patient is suffering from wheat allergy.

In addition to being a nutrient-dense food, maize is also versatile and can be used in a variety of dishes. It can be ground into flour for bread or tortillas, popped for a snack, or boiled and mixed with other ingredients for a savory dish. As this maize is not only nutritional and versatile crop but a sustainable too. Since groundwater of India is declining and, in the rice, growing areas dependent on groundwater, it is the perfect crop to be grown because of its low requirement of water as compared to rice. In terms of production and productivity it also surpasses other major crops. For these reasons, promoting the consumption of quality protein maize or biofortified maize, can have a positive impact on both the environment and society. Furthermore, incorporating quality protein maize into our diets and in the midday meal of children's can provide us with essential nutrients and improve our overall health.

Furthermore, maize is apparent to have a number of advantages by smallholder farmers also. By supporting local farmers who grow maize, we can contribute to the development of rural communities by the setup of small-scale industries of QPM products. A large number of value-added products of quality protein maize can be developed viz., QPM dalia, ladoo, sev, halwa, flour etc. It can be used in all the ways like normal maize could be and can help farmers improve their productivity and income. In conclusion, we have explored the various aspects of maize as a nutricereal. Considering all these points, it is clear that quality protein maize has the potential to be considered as a nutricereal. Its nutritional value, versatility, and sustainability make it a valuable addition to any diet. By promoting its consumption, we can not only improve our own health but also contribute to a more sustainable future.

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Blockchain Technology in Agriculture: Enhancing traceability and transparency in the Supply Chain

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In recent years, the agriculture industry has faced numerous challenges in ensuring the traceability and transparency of its supply chain. From food safety concerns to fraudulent practices, the need for a robust system that can provide accurate and reliable information has become increasingly important. This is where blockchain technology comes into play. Blockchain, a decentralized and transparent ledger, has the potential to revolutionize the way we track and verify agricultural products, ensuring trust and accountability throughout the supply chain (Akella *et al.*, 2023).

Blockchain technology, also referred to as distributed ledger technology, is a type of public bookkeeping protocol executed by a network of computing systems. The networked computing systems execute a pre-determined protocol to maintain a record of transactions, which are stored in "blocks." Each block of the blockchain includes data (e.g., one or more records/transactions), a hash value of the immediately preceding block, and a hash value of the contents of the current block. Blockchain is capable of providing immutable data records and traceable transaction history, which provides great potential to enhance efficiency, transparency, and traceability (Tripoli and Schmidhuber, 2018).

Blockchain technology has recently surfaced as a possible solution that might be implemented in food supply chains in order to improve transparency and traceability. Blockchain technology enables full end-to-end transparency and accountability regarding the origin, quality, and distribution of agricultural products (Bai *et al.*, 2019). This is a significant step forward in the industry. The possibility that solutions based on blockchain technology could increase agricultural output, transparency, and long-term viability is an appealing prospect. Farmers, processors, distributors, retailers, and ultimately consumers are all links in the supply chain for global agriculture. Farmers come first in the chain, followed by distributors, then retailers, and finally consumers. Along the whole supply chain, it is critical for there to be complete traceability and transparency of agricultural products (Cai *et al.*, 2019). This is important from both a quality and a sustainability standpoint.

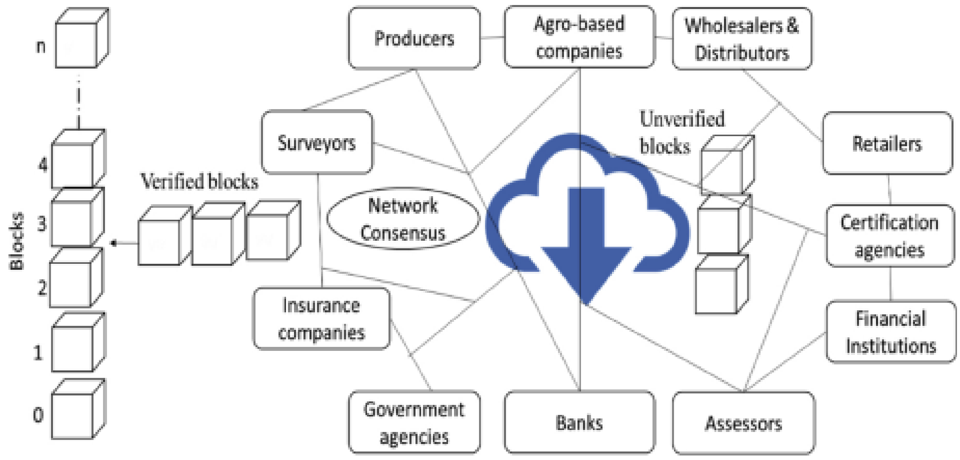

Fig. 1: Blockchain technology in agriculture supply chain (Kamble *et al.*, 2019)

Need for traceability and transparency

The major challenges involved in Agri-food supply chains (AFSCs) include product loss or theft, adulteration, the illegal sale of terminated (or fake) products, illegal labeling, and difficulty in fulfilling customer requirements. Therefore, the traceability system has become a critical component of modern AFSCs (Yao *et al.*, 2022). Information is vital for reducing costs, improving yield and quality (while reducing waste), increasing employees' productivity, and enhancing customer service. It helps to render the supply chain (and its stakeholders) more competitive in the market (Rahman *et al.*, 2021). Traceability, transparency, and auditability are important features that enable one to control (maintain) food quality and safety and increase customer satisfaction (Feng *et al.*, 2020). Therefore, innovative logistics information systems in AFSCs should effectively provide the abovementioned features.

In modern businesses, market competition is enacted between supply chains rather than individual companies (George *et al.*, 2019). In this regard, real-time information availability, safety, and reliability are highly important for food supply chain efficiency (Zhang *et al.*, 2022). Therefore, an effective traceability system that avoids information islands in the AFSC is becoming an important tool that can help to fulfill the requirement for the integration of blockchain technology (BCT) into traceability systems.

Challenges in the traditional system:

As shown in Figure 2, supply chains have a traditional structure. A central database containing data regarding all processes is created by using this approach. An administrator manages the database. Several limitations apply to this approach. This system uses a server to manage the database. Therefore, if that server fails, the entire system will go down. An administrator who is dishonest could change the data without the stakeholder's knowledge (Mirabelli & solina, 2019). Those manipulations are inadmissible to track back. Thus, this centralized approach is opaque and untraceable as well. Among the major challenges of the traditional supply chain ecosystem are traceability of products, transparency of stakeholders, and trust in collaborative systems. In the traditional approach, there are a lot of intermediaries, causing trust problems and performance problems (Dutta *et al.*, 2020). Various supply chain entities include farmers, distributors, retailers, etc. Consequently, any outbreak involving food products will be extremely difficult to trace (Salah *et al.*, 2019). It is essential to examine the functional impact, social impact, and economic impact of emerging technologies in the supply chain ecosystem. Furthermore, the traditional supply chain ecosystem is highly centralized. This leads to trust issues when multiple organizations collaborate. A centralized process makes it easy to manipulate data without the knowledge of other stakeholders. Any carelessness in the food supply chain may put the lives or health of people at risk. This is a big concern when it comes to traceability. Trust issues within the supply chain can result in significant losses for companies. Companies put the utmost effort into creating trust among consumers. Providing access to data while protecting it from being altered by others should resolve these issues. With blockchain technology, supply chain performance can be improved, and issues can be eliminated. Furthermore, it has some features that make it useful for addressing supply chain concerns beyond its use of distributed ledger technology. As a result of its immutability and distributed nature, it provides a secure and reliable record that cannot be altered or altered. (Ferrag *et al.*, 2020).

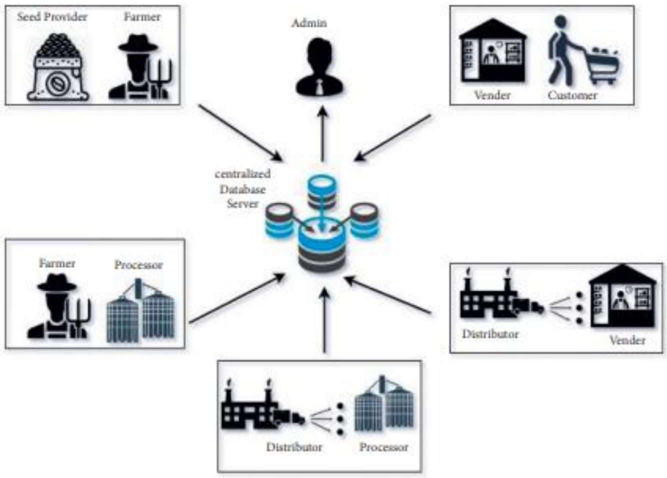

Fig. 2: Traditional supply chain (Ehsan *et al.*, 2022)

How blockchain works:

Blockchain is an immutable and distributed digital ledger containing chained data blocks (Varavallo *et al.*, 2022)(see Figure 3). It is a ledger with a growing list of data records that are validated by the P2P network members/nodes. In blockchain technology (BCT), a chain of data is created by immutably linking a new block with the previous block. Once data have entered the Blockchain, no one can alter them, as an attempt to corrupt the data in one of the blocks will render the following blocks invalid. This property of BCT enables one to tackle data modification problems.

Advantages of blockchain technology in agriculture

• Transparent procurement: The blockchain's distributed ledger can help in the process of procurement. This ledger is shared among all the stakeholders and continuously updated so that each transaction is visible to all. Companies can easily verify their orders by a distributed ledger.

• Smart contracts for payments: Blockchain's integration with smart contracts automates invoice generation and payment upon task completion, reducing manual processing time and ensuring swift payment settlement.

• No more fraud by rogues: Blockchain's decentralized ledger, updated through consensus among connected nodes, prevents rogue transactions and requires agreement from all stakeholders for execution.

• Provenance tracking: The blockchain-supported solution has a feature of provenance tracking. It means any transaction can be traced back to its time of origin from its current instance (Kouhizadeh *et al* ., 2020).

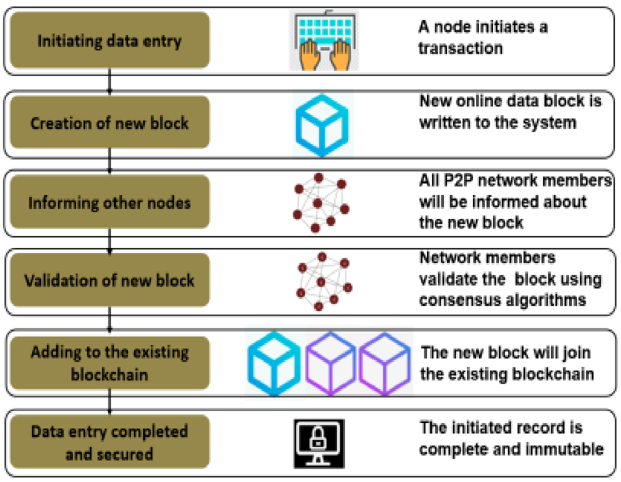

Fig. 3: Blockchain working (Bosona & Gebresenbet, 2023)

Use Cases and Implementation

- Blockchain implemented on a double chain structure helps increase openness and security of transactions, and privacy of enterprise information and can achieve proper resource allocation among all stakeholders in the agriculture sector.
- It also enhances the overall efficiency of the system, eases business expansion, and increases the throughput and credibility of the related platforms (Hasan *et al.*, 2019).
- Blockchain is being used to deal with the trust issues that customers are having in the organic product SCs (Khare and Mittal, 2019).
- Along with efficiency and product tracking, it also helps to maintain a fair relationship between small farmers and big buyers and democratize the supply process (Kshetri, 2019).
- Using blockchain can solve the problem of adulteration and tampering on a large scale by facilitating end-to-end traceability (Behnke and Janssen, 2019).
- A successful application case is on the startup, AgUnity which is safeguarding farmers using blockchain (Helo and Hao, 2019). Another example is Prochain, a new transparent and traceable SC system that has been conceptualized to help cover all the aspects of SC. As food safety is critical to all walks of life, blockchain can directly improve social welfare.

Conclusion

Blockchain technology has the potential to transform the agriculture sector by increasing transparency, traceability, and efficiency in the supply chain. It offers the ability to provide consumers with a clear view of the journey of their food, fostering trust and confidence, while also enabling quick identification and resolution of issues such as contamination or product recalls. Blockchain can reduce fraud, streamline operations, and cut administrative costs by eliminating intermediaries, benefitting both farmers and consumers. It also has the potential to provide financial services to underserved farmers, promote sustainable agricultural practices, and improve data-driven decision-making for precision agriculture. Furthermore, blockchain simplifies international trade and compliance with global regulations, making it easier for agricultural products to access global markets.

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Pioneering Sustainable Agriculture for a Greener Tomorrow

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In the lush landscapes of Chinnappampalayam Village, situated in Coimbatore District, a remarkable transformation story of a farmer, Surendaran, is getting unfolded, whose unwavering dedication to sustainability has turned a 10-acre field into a thriving agricultural paradise. As we delve into the life and work of this visionary farmer, we uncover a remarkable journey that began with a single class and leading to an organic revolution that continues to inspire others and protect the environment.

A Visionary Unveiled

Our story was begun in 1993, when a single class led by an earthworm researcher named Sultan Ismail sparked a fire of curiosity and inspiration in a humble farmer from Chinnappampalayam. Little did he know that this class would sow the seeds of change that would later revolutionize his approach to farming. It was when that he heard of the wonders of organic farming for the first time and decided to embark on a path that less travelled.

Certified Organic

Fast forward to 2001, our farmer's commitment to organic farming had already begun bearing fruits. His tireless efforts and dedication earned him recognition from the Tamil Nadu Government, who officially certified him as an organic farmer. His journey was gaining momentum, but the best was yet to happen.

Inspired by Legends

In 2007, a turning point came when he attended a life-changing class on organic farming conducted by none other than Thiru. Nammalvar, widely regarded as the Father of Organic Farming. It was the day that shaped his destiny, filled him with new ideas and inspired him to take his farm to the next level. Armed with this newfound knowledge, he was set out to reshape his farm into an exemplar of sustainability.

A Symphony of Crops and Livestock

Today, our farmer's plot is an intricate blend of crops and livestock. At its heart lies a lush grove of coconuts, their graceful fronds reaching towards the sky. Alongside them, the rich, dark leaves of cocoa plants cast their shade over the fertile soil. These two crops (coconuts and cocoa) dominate a significant portion of his farm's landscape.

But there's more to this landscape that meets the eye. Livestock, including milch cows and goats, coexist harmoniously with the crops. What sets this farm apart is the way in which everything is interconnected – a self-sustaining feeding cycle where nothing goes waste.

Water Management for Sustainability

In this journey towards sustainability, water management plays a pivotal role. The introduction of precision irrigation system (drip irrigation) helps minimize water usage and optimize its distribution. Additionally, a farm pond constructed under a government scheme ensures a consistent water supply, reducing dependency on external sources and supporting the farm's needs.

Challenges along the Way

The road to sustainable farming was not without its challenges. The overuse of inorganic fertilizers had taken its toll on soil health, a common problem among many farmers, posing a long-term threat to agriculture. Hybrid crops, while potentially high yielding, demanded substantial inputs and investments, adding financial pressure to an already challenging situation. And then there was the ever-present concern of labour shortages due to rural-to-urban migration, with labourers demanding higher wages, further squeezing the farmer's resources.

Innovative Solutions to Age-old Challenges

This farmer, however, is not one to back down from a challenge. He met these hurdles head-on, ingeniously integrating various components into his farming practices to overcome these difficulties:

- Beekeeping, Panchagavya & Jeevamirtha preparation and a Gobar gas units have all found a place on this forward-thinking farm.

- A bio-decomposer unit handles farm waste, converting it into valuable resources.

Fig 1: The decomposer unit that reproduces valuable waste

- A Gobar gas unit produces enough gas for domestic use, eliminating the need for LPG gas cylinders since 2010.

Fig 2: Gobar gas unit

- A unique approach that combines gas slurry and urine; upon applying it to crop plants through drip irrigation, leads to impressive results.
- Panchagavya that serves as a versatile tool, doubling as a biopesticide and crop booster.
- Poultry droppings are cleverly integrated as a nitrogen source, thereby reducing the reliance on external nitrogenous fertilizers.
- Dairy farming is not merely a source of income; but it enhances soil quality, nutrient recycling and meets household energy needs.
- Beekeeping thrives on the farm, providing honey as well as contributing to pollination.
- Waste from the farm is recycled efficiently through vermicomposting.

Precision Management of Crops

Precision management extends to crops too. Meticulous attention is paid to the specific needs of each crop. Magnesium sulphate is applied when coconut leaves show signs of yellowing. For cocoa, only dried cow dung is used. Areca nut palms receive cow dung and muriate of potash. By aligning crop management with the specific needs of each plant, the farmer saves money and ensures optimal growth.

Bountiful Results

The results of these innovative practices are nothing short of spectacular:

- On average, the farm yields 140-150 coconuts per palm annually, each provides a stable income upon selling.
- Cocoa trees produce around 800g of dried beans per tree, fetching excellent prices.
- Animals are fed with farm-grown greens and homemade animal feed, substantially reducing the maintenance costs.
- Honeybee colonies yield around 850 grams to 1 kg of honey each, attracting buyers willing to pay premium prices.

Impact on the Environment

This sustainable approach isn't just about profits; it leaves a profound impact on the environment as well. There's been a significant increase in income, but more importantly, a substantial improvement in the quality of the environment due to the adoption of Integrated Farming Systems (IFS).

Lessons in Sustainability

The lessons learned on this remarkable journey encompass a range of crucial aspects:

- IFS enhances productivity, recycling of resources and reduces the dependency on external sources.
- This approach leads to a notable reduction in production costs, enhancing the efficiency of resource utilization.
- The diversification of crops reduces investment risks and promotes sustainability.
- This journey has resulted in increased income and an improved standard of living.

A Farmer's Reward

The story of this farmer serves as a testament to the rewards of hard work, determination and a deep commitment to the environment. By choosing the path of sustainability, he has achieved not only personal success but also made a significant contribution to the land he holds dear.

And so, in the verdant fields of Chinnappampalayam Village, a farmer's journey continues, echoing a simple yet powerful truth: If you think that the thing, you're doing is right, one day, you will undoubtedly reap the benefits of your hard work. This farmer's story is living proof that a commitment to sustainability can truly bear fruits and enrich both the land and those who tend to it.

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Creative Application of Mustard Straw and Stalk

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Rapeseed mustard have always stood high among other oilseeds be it interms of its oil quality or its seed meal rich in bioactive compounds. The agro-waste after mustard harvest is left for decay in field or it is burnt without serving any purpose which instead creates environmental pollution. It was estimated that approximately 22 mt of mustard straw and stalk (annually) is available in India (Tripathi et al. 2008). According to Pal et al. (2013) Indian mustard straw and stalk constitutes about 70% of total plant minus the seeds. According to studies by Maiti et al. (2007) mustard straw and stalk has higher content of cellulose (48.5%) and hemicellulose (29.6%) in comparison to agro-waste residue of rice straw (cellulose 28.5%, hemicellulose 24%), wheat bran (cellulose 30%, hemicellulose 27.2%) which can act as cheap source for production of lignocellulolytic enzymes and alternative use to generate bioethanol. Fossil fuels globally are still the major source of energy with consequences for their effect on climate change. Alternative uses has always been in focus like the use of biofuel-biodiesel and bioethanol. Lignigication of straw residues have received wide attention for used in food industries. In oilseed crops the xylo-oligosaccharide contains more acetal and uronic acid substituents in comparison to other cereal crop, which adds to the advantage in food industry (Pronyk and Mazza 2012). Mustard straw and stalk being rich in cellulose and hemicellulose content serve as carbon source by the fungus for production of enzymes such as glucosidase, xylanase and xylosidase in submerged fermentation (Pal et al. 2013). Agricultural crop wastes, for example, provide a low-cost feedstock for the biological synthesis of fuels and chemicals, as well as economic, environmental, and strategic benefits (van Wyk, 2001). In India, mustard stalk and straw (MSS), devoid of seed, account for approximately 70% of the total plant and are considered agricultural waste. MSS is also not used as cattle feed and is either left in the field to decay naturally or is burned without serving any purpose other than adding to environmental pollution.

Mustard being a member of brasicasea family has unique identity with the presence of glucosinolate. The phytochemical role has been recognized as anti-insecticidal and anti-herbivore activity. Pyrolysis of mustard straw has been found as bio-oil for insecticidal activity (Suqi et al. (2014). The conversion of mustard straw through thermochemical means is known as pyrolysis.

Another alternative for recylcling of organic waste is composting, this is widely accepted practice in India for agriculture use. The utilization of mustard straw agro- waste for alternate use will not only serve as a source of income but also reduce environmental pollution.

Mustard straw as discussed earlier, has high content of cellulosic compounds and less of protein content rendering it unpalatable and indigestible for the ruminants. Various chemical methods have been used to improve the nutritive value of mustard straw. One of the biological methods is fermentation of mustard straw with white rot fungi. Through this process it renders the straw fiber more accessible to rumen enzymes for subsequent digestion. The extent of mustard straw quality fermented with white rot fungi is regulated by relative degradation of lignin and carbohydrates besides the protein production (Misra et al.2006). The performance was found to be favourable in terms of dry matter, crude protein content and digestibility of mustard straw. This shows the ample uses of dry mustard straw for various functions instead of allowing it to decay in the field.

Wood industry is facing tough competition to meet the demands of the population. Many studies have demonstrated the alternative use of wood by substituting it with waste of annual plants for wood-based board industry and paper industry (Dukarska et al. 2015). Study by Dukarska et al (2015) showed comparable chemical composition to that of wood with its added advantage is the shape of the straw particles (slender and flatness) similar to the particles from the wood particle core layer.

Table 1. Alternative uses of or recycling of mustard straw and stalk residue

SL. No.		Brief description	References
1.	Composting	Composting is one of the common ways to recycle organic waste. The humus in this waste is of great value for maintaining soil fertility.	Raj and Antil (2011)
2.	Lignocellulosic bio- refinery	Lignocellulosic biomass serves as the most abundant material in the world. Lignocellulosic biorefinery coverts lignocellulosic biomass to production of energy and chemical needs	Zhang et al. (2007)
3	Prebiotic compounds	Lignification of mustard straw leads to Xylo oligosaccharide with high substituents of acetyl and uronic acid adding value for use in food applications as prebiotics.	Pronyk and Mazza 2012
4	Lignocellulolytic enzymes	Mustard straw and stalk (MSS) are a novel source of lignocellulolytic enzymes and a saccharification substrate. MSS is a suitable candidate as a low-cost agro-residue for the manufacture of lignocellulolytic enzymes by T. clypeatus, and it may also be used to make bioethanol.	Pal et al. (2013)
5	Carbohydrate source	Because of its high sugar content serve as source for extraction of carbohydrates for use in food industry.	Pronyk and Mazza(2012)
6	Pyrolyzed bio-oil	Mustard pyrolyzed-oil as an alternative use for chemical insecticide	Suqi et al. (2014)
7	Protein rich animal feed	Mustard residues fermented with various fungi may be converted to protein-enriched food	Misra et al. (2006)
8	Particle board industry	The boards made up of even 100% mustard straw particles met the requirements of EN312 standard for boards intended for general use in dry conditions. Reduction of use of mustard straw to 75% allowed for the production of P2 boards-boards used for interior design like furniture in dry conditions.	Dukarska et al. (2015)

Conclusion

The recycling of agro-waste is the need for the hour through ecofriendly, viable and socially accepted technologies to prevent the large-scale accumulation of these waste in order to overcome pollution and disposal problem.

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Satellite Farming

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An agricultural management strategy that is centred on monitoring, measuring, and responding to crop variability within and between fields is called "satellite farming," "precision agriculture," or "site specific crop management" (SSCM). Precision agriculture research attempts to build a decision support system (DSS) for total farm management to optimise input returns while conserving resources. It is also described as an information and technology-based farm management approach that finds, analyses, and manages variability within fields for optimal profitability, sustainability, and preservation of the land resource. Satellite farming is one of the most innovative and modern forms of organic farming that are becoming more and more popular in the twenty-first century. Reducing the use of farm equipment, water, fertilisers, pesticides, and herbicides can serve as an example of how precision agriculture can be advantageous for both the environment and the economy. Data gathering and processing could be automated and made simpler with precision agriculture. Precision agriculture divides a field into "management zones" based on many factors such as crop productivity, yield rates, pest infestations, pH of the soil, and nutrient position.

Aspects of satellite farming

A broad range of topics are covered by aspects of satellite farming, including the variability of soil resources, weather patterns, plant genetics, crop diversification, machinery performance, and the physical, chemical, and biological inputs used in crop production. The general public believes that satellite farming is limited to large holdings found in wealthy countries. The kind and size of farms do not preclude the deployment of a well-thought-out satellite farming system because satellite farming is adaptable by nature. It offers an opportunity to improve agricultural productivity and product quality. The capacity of satellite farming to maintain uniformity throughout regional and farm-level fluctuations in sowing, fertiliser and pesticide treatment, and harvesting is one of its intrinsic benefits.

Need for satellite farming

Satellite farming offers potential economic and environmental benefits because it requires less water, fertiliser, pesticides, herbicides, and other farm equipment. Rather than controlling an entire field based on some hypothetical average state that may not exist anywhere in the field, a satellite farming technique identifies site-specific differences within fields and adjusts management activities accordingly. Most farmers know that their farms yield differently depending on the topography. These variations may be related to environmental factors, soil conditions, or management strategies. These days, with farms growing in size and the cultivated zones shifting due to annual lease agreements, it is difficult to hold onto that level of field condition information. Data processing and collecting could be automated and made simpler with precision agriculture. It enables the efficient and timely application of management choices on smaller fields inside bigger fields.

Component of satellite farming:

There are several parts to satellite farming, including computers, Global positioning system (DGPS) with differential positioning; remote sensing; geographic information system (GIS); and variable rate applicator

Computers

Satellite farming is supported by a number of technologies, but computers are the most important since they allow precision agriculture. Successful satellite farming requires the acquisition, management, analysis, and production of large amounts of temporal and spatial data. Mobile computing solutions were necessary for farming operations to be carried out while on the go because the farm's office's desk top computers were inefficient.

Remote sensing

For many years, the process of gathering data from a distance—known as remote sensing—has been used to identify crop species and pinpoint fields of stress. The detection and measurement of photons originating from distant materials constitute the process of remote sensing. These photons may be identified and classified based on their class, kind, substance, and spatial distribution; most of them are employed to track reflected radiation (Frazier *et al.*, 1997).

Geographic information system (GIS)

This approach to computerising maps works well. An agricultural GIS's ability to store layers of data such as yields, maps from soil surveys, information collected by remote sensors, crop monitoring reports, and levels of soil nutrients is essential. Thanks to GIS technology, the manager can save field input and output data as separate layers of a map in digital maps and access and use this data for decisions on the next input allocation.

Fig 1 : Application of fertilizer through drones

Source: eos.com

Differential Global Positioning System (DGPS)

With an accuracy of between 100 and 0.01 metres, this navigation system—which is based on a network of earth-orbiting satellites—allows users to collect positional data (latitude, longitude, and elevation) almost instantly (Lang, 1992).

Variable rate applicator

With variable rate technology, the rate of input adjusted in real time with the field to account for changing factors that affect the most efficient rate of application. It has the potential to raise or, in the best scenario, maximise the efficacy of input and profitability of particular regions by concentrating applications where they are needed and at the optimum rate.

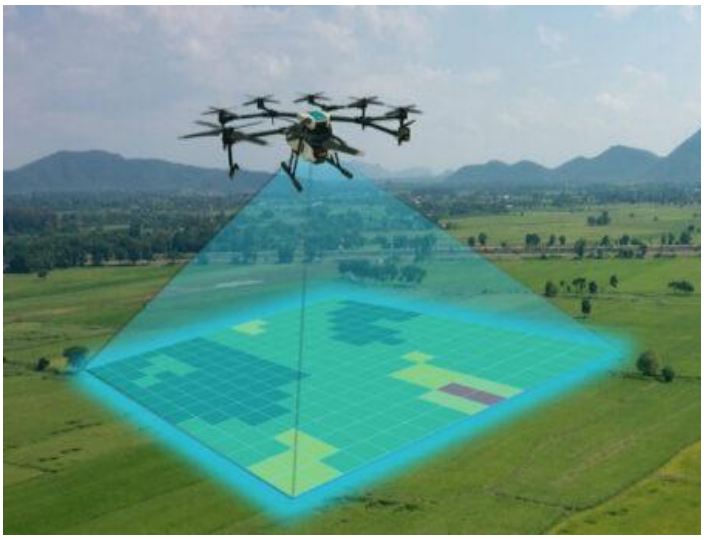

Fig 2: Crop health monitoring

Source: xyonix.com

Fig 3: Introducing precession agriculture technology in fields

Source: extensionaus.com.au

Present scenario in India

While satellite farming has gained a lot of attention in developed countries, it is still relatively new in developing nations like as India. The Central Potato Research Institute in Shimla and ISRO's Space Application Centre has launched a study to investigate the application of remote sensing in precision agriculture. Precision agriculture research has already started at a number of Indian research institutes. An investigation has been initiated by the Place Application Centre (ISRO), Ahmadabad, in the Central Potato Research Station farm in Jalhandhar, Punjab, to explore the role of sensors in mapping variability with respect to place and time. The Indian Agricultural Research Institute has created a plan to carry out exact farming experiments on the institute's land. The Project Directorate for Cropping Systems Research (PDCSR), Modipuram and Meerut (UP), in collaboration with the Central Institute of Agricultural Engineering (CIAE), Bhopal, also initiated variable rate input application in a number of cropping systems (Hazarika and Roy, 2023)

Opportunities

Pests and diseases cause large losses in Indian agriculture. When remote sensing can help identify small problem areas brought on by infections, the timing of fungicide applications can be improved. Recent research conducted in Japan suggests that radio-controlled aeroplanes and near-infrared narrow-band sensors can be used to detect early signs of agricultural stress or damage. In a similar vein, it has been shown that using GIS in conjunction with aerial video footage to precisely map and identify black fly infestations in citrus farms allows for targeted pest management. Precision technologies can help growers by adjusting the timing, quantity, and position of water to more profitably arrange irrigation in semi-arid and arid tropical climates.

Conclusion

Satellite farming has a lot of promise for adoption even if it is still in its infancy in many developing countries, including India. Many developing countries rely heavily on agriculture as a source of pollution; therefore farmers will not adopt precision farming unless it provides a greater rate of return than their current practises, or at least one that is equivalent. Thus, during the early phases of adoption, it is essential to have support from both the public and private sectors. Remembering that not every farm can benefit from every component of precision farming is crucial. For example, the best degree of spatial management or the use of variable-speed applicators is not always necessary on Indian farms.

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Cocoponics: A Sustainable Approach to Agriculture

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Abstract

In an age when sustainable agriculture is becoming increasingly critical, innovative methods of growing food are gaining prominence. One such method is Cocoponics, a fusion of two seemingly unrelated elements – coconuts and hydroponics. Cocoponics offers a sustainable and eco-friendly way to produce food, particularly in regions with limited resources and environmental challenges. Cocoponics is also a very versatile growing method. It can be used to grow a wide variety of crops, including fruits, vegetables, herbs, and flowers. Cocoponics can be used to grow plants indoors or outdoors. It is also a good option for urban farming, as it can be used to grow plants in small spaces, such as balconies and rooftops.

Introduction

Cocoponics is a system of cultivating plants, typically vegetables and herbs, without using soil. Instead, it leverages the husks of coconuts, or coconut coir, as a growing medium. Coconut coir is an excellent alternative to traditional soil as it is lightweight, pH neutral, and rich in essential nutrients. It is a waste product of the coconut industry and, therefore, readily available and sustainable. Cocoponics is a sustainable way to grow food that uses coco coir as a growing medium. Coco coir is a byproduct of coconut processing, making it a renewable and eco-friendly alternative to traditional soil. Cocoponics is a type of hydroponics, which is a method of growing plants without soil. Instead, plants are grown in a nutrient-rich water solution.

Cocoponics has several advantages over traditional soil-based farming methods. First, coco coir is a very efficient growing medium. It can hold up to four times its weight in water, which means that plants require less water to grow in coco coir. Second, coco coir is very well-aerated, which is essential for healthy root growth. Third, coco coir is resistant to pests and diseases.

Key Components of Cocoponics

Coconut Coir: The fundamental component of Cocoponics, coconut coir is an eco-friendly and renewable resource.

Hydroponics: Cocoponics incorporates hydroponic principles, meaning that plants are grown in a nutrient-rich water solution rather than soil.

Controlled Environment: Cocoponics systems are often designed in controlled environments like greenhouses to optimize growing conditions.

Why Cocoponics is a Game-Changer

Efficient Use of Space: Urban gardeners often deal with limited space, making traditional soil gardening challenging. Cocoponics solves this problem by allowing plants to grow vertically, saving space and maximizing the yield per square foot.

Water Efficiency: In a world increasingly concerned with water conservation, Cocoponics is a water-wise solution. Unlike traditional soil gardening, which can be water-intensive, Cocoponics recirculates water and nutrients, reducing water usage significantly.

Nutrient Control: With Cocoponics, you have precise control over the nutrients your plants receive. This results in faster growth, healthier plants, and increased crop yields. You can adjust nutrient levels based on the specific needs of your plants.

Reduced Pest and Disease Pressure: Since Cocoponics eliminates the need for soil, it minimizes the risk of soil-borne pests and diseases. This reduces the need for chemical pesticides and makes your urban garden more eco-friendly.

Year-Round Gardening: Cocoponics systems can be set up indoors or in greenhouses, allowing for year-round gardening. This is particularly important for urban areas with harsh winters or limited growing seasons.

Benefits of cocoponics

Sustainability: Coco coir is a renewable and eco-friendly growing medium. It is also a byproduct of coconut processing, which means that it would otherwise be discarded.

Efficiency: Coco coir is a very efficient growing medium. It can hold up to four times its weight in water, which means that plants require less water to grow in coco coir.

Versatility: Cocoponics can be used to grow a wide variety of crops, including fruits, vegetables, herbs, and flowers. Cocoponics can also be used to grow plants indoors or outdoors.

Productivity: Cocoponics systems can produce higher yields than traditional soil-based farming methods.

Pest and disease resistance: Coco coir is resistant to pests and diseases. This reduces the need to use pesticides and fungicides.

Challenges and Considerations

While Cocoponics offers several advantages, it has some challenges too:

Initial Investment: Setting up a cocoponics system can be costly, primarily due to the construction of controlled environments and the purchase of equipment.

Technical Knowledge: Successful cocoponics cultivation requires expertise in hydroponics and controlled environment agriculture.

Nutrient Management: Careful management of the nutrient solution is crucial for optimal plant growth and avoiding nutrient imbalances.

Energy Consumption: Controlled environments typically require electricity for lighting, heating, and cooling, which may increase energy consumption.

Applications of Cocoponics

Cocoponics is versatile and can be applied in various contexts, including:

Urban agriculture: Cocoponics systems are ideal for urban settings where space is limited, and sustainable food production is essential.

Remote areas: In regions with harsh climates or poor soil quality, Cocoponics can provide a reliable source of fresh produce.

Community gardens: Cocoponics can be adapted for community gardens, fostering local food production and reducing food miles.

Conclusion

Cocoponics is a sustainable and innovative approach to agriculture for food production that addresses some of the pressing challenges of traditional agriculture. By utilizing coconut coir and hydroponic techniques, it offers water efficiency, space savings, and year-round growing potential. While there are challenges to overcome, the promise of cocoponics as a solution for sustainable food production is evident. As our world grapples with environmental and resource constraints, the development and adoption of such practices are crucial steps toward a more sustainable and food-secure future.

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Cherry Propagation Techniques: A Comprehensive Guide

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Cherries are thought to be native to Europe and western Asia and are now grown widely around the world. Cherries belong to be Rosaceae family and the genus is Prunus, subspecies Cerasus and section Eucerasus. There are two mainly species of cherry fruits referenced such as sweet (*Prunus avium*) and sour (*Prunus cerasus*) cherries. Among the two species, of global trading importance are sweet and sour cherries. Cherry fruits are cultivated worldwide and mostly two cultivars are used for human consumption and processing. Both sweet cherry (Prunus avium) and sour cherry (*Prunus cerasus*) enjoy great popularity world due to rich refreshing flavour and recognised health benefits. Commercial cultivation of sweet cherry is generally more difficult and expensive than sour cherry as high levels of care must be taken throughout the supply chain to achieve premium quality fruit for serving in the fresh market. In both sour and sweet cherry, the Properties chemical composition and uses is different. Sour cherries are mostly used in processed form such as canned products and juices. In comparison with sour cherries have a lower content of simple sugar (8g to 100/g), sweet cherries have a higher content of simple sugar (13g-100/g).

Major cherry Producing countries worldwide

Turkey was the largest producer of cherries in the world, producing about 833 thousand metric tons. The European Union was the second leading producer, with 831 thousand metric tons produced.

Major cherry Producing states in India

The Kashmir valley contributes to 95 percent of the total cherry production in India. Jammu & Kashmir, Uttarakhand, Himachal Pradesh, Uttar Pradesh and Assam are the popular cherry producing states in India due to profitable income for every farmer. Kashmir annually sends around 3,500-4,000 metric tonnes of cherries to other states of India.

Cultivation Area of cherry

Cherries are primarily grown in the northern regions of India, particularly in the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. In Jammu and Kashmir, the districts of Srinagar, Anantnag, Budgam, and Baramulla are the major producers of cherries. In Himachal Pradesh, the districts of Shimla, Kinnaur, and Kullu are known for cherry cultivation. In Uttarakhand, the districts of Nainital and Dehradun are the major cherry-producing areas. Additionally, some parts of Punjab and Haryana also have small-scale cherry cultivation.

Climate Required

Cherries require cool weather conditions with temperatures ranging between 15°C to 25°C during the growing season. They also require a period of winter dormancy with temperatures below 7°C to induce flowering.

Soil Condition

The soil should be well-draining, rich in organic matter, and have a pH between 6.0 to 7.5. Adding compost or manure to the soil before planting can help improve soil fertility.

Nutritional value

Raw sweet cherries are 82% water, 16% carbohydrates, 1% protein, and negligible in fat (table). As raw fruit, sweet cherries provide little nutrient content per 100 g serving, as only dietary fiber and vitamin C are present in moderate content, while other vitamins and dietary minerals each supply less than 10% of the Daily Value (DV) per serving, respectively (table). Compared to sweet cherries, raw sour cherries contain 50% more vitamin C per 100 g (12% DV) and about 20 times more vitamin A (8% DV), beta-Carotene in particular (table).

Varieties of Cherries Grown in India

There are several varieties of cherries that are grown in India, mainly in the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. Some of the popular varieties of cherries grown in India include:

- **Sweet cherries:** Sweet cherries are the most popular type of cherries grown in India. Some of the common varieties include Lapins, Bing, Rainier, and Stella.
- **Sour cherries**: Sour cherries, also known as tart cherries, are also grown in India, but are less common than sweet cherries. Montmorency is a popular variety of sour cherries grown in India.
- **Wild cherries:** Wild cherries are also found in India, particularly in the Himalayan region. They are smaller in size compared to cultivated cherries and have a sour taste. The wild cherry varieties found in India include Prunus coracoids and Prunus avium.
- **Hybrid cherries:** Hybrid cherries are also grown in India, which are a cross between sweet and sour cherries. The hybrid varieties include Regina and Kordia.

Propagation of Cherry Plants

- **Grafting:** This is the most common method of propagating cherry plants. In this method, a scion (a young shoot) of the desired variety is grafted onto a rootstock of a compatible cherry tree. The graft union is wrapped with a grafting tape and allowed to grow until the two parts have fused together.
- **Budding**: Budding is another method of grafting, in which a bud from the desired variety is grafted onto the rootstock. This method is usually done in late summer or early fall.
- **Cuttings:** Softwood cuttings can be taken from cherry plants in early summer and rooted in a propagation bed or a pot filled with potting mix. Hardwood cuttings can also be taken in the winter and rooted in a greenhouse or propagation bed.
- **Layering:** In layering, a low branch of the parent tree is bent down and covered with soil. The branch will root and can be cut off from the parent tree to form a new plant.

Fig 1: Grafting propagation technique

Fig 2: Budding propagation technique

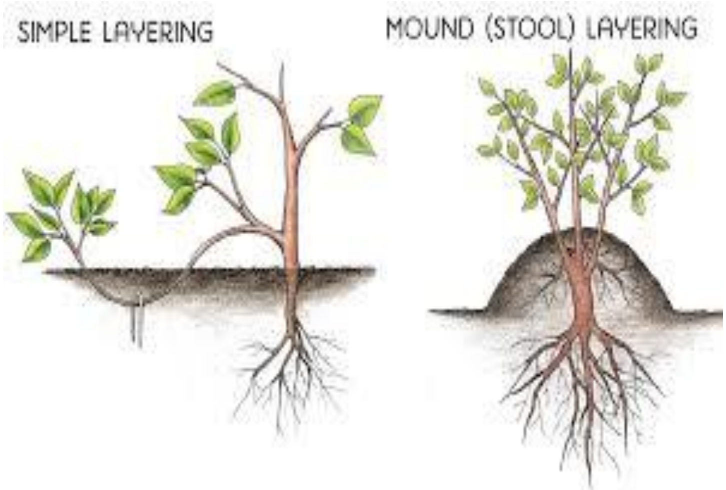

Fig 3: Cutting and Layering propagation techniques

Health Benefits of cherry fruits:

- Cherry are a good source of vitamin C and fibre
- Cherry help in reducing inflammation
- Cherry prevents muscle damage
- Cherries may improve brain function
- Cherries may help better sleeping
- Cherries reduce the risk of heart stroke
- Cherries may prevent cancer

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Scaling-Up Indigenous Tree *Gmelina Arborea*-Based Agroforestry System in Northeast India

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Gmelina arborea, also called white teak or gamhari, is a rapidly growing deciduous tree that is native to India and can grow up to 1500 meters in elevation. It is a member of the Verbenaceae family and has gained popularity in India for its many uses, high-quality wood, and simple and quick financial returns. It is valued equally as a species of wood and as a medicinal plant. It is utilized in the production of traditional drums, pulp, particle board, plywood, matches, carpentry, packing, firewood, and poles in addition to furniture. According to Indian medical systems, the tree is also a significant medicinal plant. In medicine, the entire plant is employed. According to Warrier et al. (2021), it has several properties such as being astringent, bitter, digestive, cardiotonic, diuretic, laxative, pulmonary, and nervine tonic.

It is planted as a garden tree or avenue in some areas. This durable, versatile tree species grows well in both tropical and subtropical climates; however, it does require a lot of light. It grows exceptionally well in humid climates with high soil depths and pH values between 5-8. It grows poorly in low-drained soil and stays stunted in poor, sandy, or dry soil. It is a kind of medium-density wood with exceptional strength characteristics (Akachukwu, 1990). As a result, it is employed in the manufacturing of medium-grade furniture in the market. The quick growth, ease of establishment, and relative pest resistance make it a good fit for agroforestry. Fast-growing, cost-effective species like this would be perfect for large-scale plantation initiatives and farm forestry.

Furthermore, the species exhibits a significant capacity for carbon sequestration. Numerous plantations drive for this species have been implemented under various afforestation projects in different northeastern regions. The forest department in Manipur has employed this species for jhum restoration and large-scale plantations under a number of schemes.

Distribution

In addition to southern China provinces, *Gmelina arborea* is naturally found in India, Myanmar, Thailand, Laos, Cambodia, and Vietnam. It grows best in the eastern sub-Himalayan tract of India, the northeastern and Bengal regions of the Himalayan tract that are moist, and the drier central regions of India. In South East Asia's tropical and subtropical regions, the plant is naturally found in semi-deciduous forests. Widespread introductions of this rapidly growing wood tree have taken place in Brazil, Gambia, Honduras, Ivory Coast, Malaysia, Malawi, Nigeria, Philippines, and Sierra Leone since the 1960s.

Gmelina arborea-based agroforestry system

A growing tendency has been observed in the selection of agroforestry as a land-use system in the recent past. Global interest in agroforestry research has grown because of its complex and varied systems, which raise important issues including carbon sequestration and nutrient cycling (Swamy and Puri, 2005). According to Tamang et al. (2021), Gmelina arborea has the capacity to retain tree carbon in the range of 54.51-59.91 and soil carbon in the range of 48.18-55.73 Mg ha^{-1}. According to a study by Swamy and Mishra (2014), the biomass of an *Gmelina arborea* based agroforestry system ranged from 9.9 Mg ha^{-1} to 21.4 Mg ha^{-1}. Intercrops such as soybean, cowpea, wheat, mustard, peanut, and black gram, are reported to be grown under such system. In the northeast, *Gmelina arborea* based agroforestry system may offer a sustainable substitute for jhum cultivation.

Conclusion

Tree-based land use systems had a significant influence on increasing productivity, storing fuel, and offering a different source of income. It is thought to be the most sophisticated and suitable technique that raises productivity and broadens the window of opportunity for profitability, resulting in increased socioeconomic, ecological, and environmental benefits. Found extensively in the wider track of India, it is necessary to upscale this indigenous species through agroforestry in various regions of northeast India.

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Biochar: An Emerging Soil Amendment Revolutionizing Agriculture

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In the ever-evolving landscape of sustainable agriculture, biochar has emerged as a promising soil amendment, offering a myriad of benefits that extend beyond conventional farming practices. As a carbon-rich material produced through pyrolysis, biochar is gaining recognition for its transformative impact on soil fertility, structure, and overall sustainability. This article explores the fascinating world of biochar and its role as an emerging soil amendment poised to revolutionize modern agriculture.

What is Biochar?

Biochar is a solid by-product obtained through the pyrolysis of biomass. A process that involves heating organic materials, such as agricultural residues or wood waste, in the absence of oxygen. The result is a stable and porous carbon-rich material with a high surface area. This unique structure makes biochar an excellent candidate for soil improvement. This carbon-rich and porous material serves a diverse array of applications, with soil improvement, remediation, and pollution control being among its primary roles. Distinct from charcoal, which is produced at lower temperatures and primarily used as solid fuel due to its high volatile matter content, biochar undergoes pyrolysis at higher temperatures. This process alters the chemical structure of biomass, leading to a significant reduction in hydrogen, nitrogen, and oxygen content, resulting in a material rich in carbon. Unlike charcoal, biochar is non-phytotoxic. Widely employed in agriculture, biochar enhances soil fertility, promotes plant growth, and provides essential crop nutrition, thereby enhancing overall farming productivity.

Production of Biochar

The process of making biochar involves the controlled hea=ting of organic materials, such as biomass, in the absence of oxygen. This process, known as pyrolysis, transforms the organic matter into a carbon-rich and stable material with various agricultural and environmental benefits. The key steps involved in the production of biochar:

1. Feedstock Selection

The first step in making biochar is selecting the feedstock, which can include a variety of organic materials such as crop residues, wood chips, sawdust, or agricultural waste. The choice of feedstock can influence the properties of the resulting biochar.

2. Preparation of Feedstock

The selected feedstock is often processed to achieve uniform particle size and moisture content. This preparation ensures a more consistent and controlled pyrolysis process.

3. Loading the Pyrolysis Unit

The prepared feedstock is loaded into a pyrolysis unit, which can take various forms such as a kiln, retort, or specially designed pyrolysis reactor. The key element in this unit is that it limits the oxygen supply during the heating process.

4. Heating and Pyrolysis:

The pyrolysis unit is then heated to a specific temperature range (generally between 350 to 700 degrees Celsius) in the absence of oxygen. This prevents the complete combustion of the organic material and leads to the breakdown of complex organic compounds into simpler forms, resulting in the production of biochar.

5. Gas and Liquid Byproducts:

In addition to biochar, the pyrolysis process produces byproducts such as pyrolysis gas and liquid bio-oil. These byproducts can also have applications, and their collection and utilization can be part of an integrated pyrolysis system.

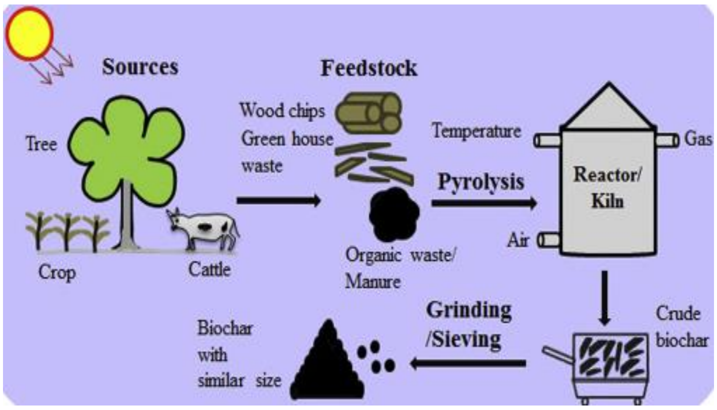

Fig. 1: Biochar Production Process

6. Cooling and Collection

Once the pyrolysis is complete, the biochar is allowed to cool before being collected. The cooling process is important to prevent spontaneous combustion and to stabilize the biochar for storage and application.

7. Post-Processing (Optional)

Depending on the intended use and specific applications, post-processing steps may be employed. These can include crushing or grinding the biochar to achieve a desired particle size or impregnating it with certain substances to enhance its properties.

8. Application

The final step is the application of biochar to the intended target, such as agricultural soils. Biochar can be incorporated directly into the soil, where it acts as a soil amendment, improving fertility, structure, and nutrient retention.

Biochar as Soil Amendment

Biochar amends the soil through a variety of mechanisms, contributing to improved soil structure, fertility, and overall health. Here's how biochar acts as a soil amendment:

1. Enhanced Soil Structure

Biochar's porous structure improves soil aeration and water retention. When incorporated into the soil, it creates a network of channels and spaces, promoting better drainage and reducing the risk of waterlogging. This enhanced structure also encourages root growth and facilitates the movement of air and water through the soil.

2. Increased Cation Exchange Capacity (CEC)

Biochar has a high cation exchange capacity, which means it can retain and exchange positively charged ions (cations) like calcium, magnesium, and potassium. This property enhances the soil's ability to hold onto essential nutrients, making them more available to plants over time.

3. Nutrient Retention and Slow Release

Biochar acts as a nutrient reservoir, holding onto essential elements like nitrogen and phosphorus. This prevents nutrient leaching, particularly in sandy or loamy soils. Over time, biochar releases these nutrients slowly, providing a sustained source of nutrition for plants.

4. Microbial Habitat

The porous nature of biochar provides a habitat for beneficial microorganisms, including bacteria and fungi. These microorganisms play a crucial role in nutrient cycling, decomposition of organic matter, and overall soil health. Biochar fosters a more diverse and active soil microbiome.

5. pH Buffering

While biochar itself is typically neutral, it can help buffer soil pH. In acidic soils, biochar can raise pH slightly, and in alkaline soils, it can act as a mild acidifier. This pH buffering capacity contributes to creating a more stable and conducive environment for plant growth.

6. Carbon Sequestration:

Biochar is a stable form of carbon that persists in the soil for an extended period. By adding biochar to the soil, carbon is sequestered, contributing to long-term carbon storage. This has implications for climate change mitigation, as it helps offset carbon dioxide emissions.

7. Disease Suppression:

Some studies suggest that biochar may have biopesticidal properties, helping to suppress soil-borne pathogens. The altered conditions created by biochar in the soil can make it less favorable for the proliferation of harmful microbes, contributing to disease control.

8. Improved Water Use Efficiency

Biochar-amended soils tend to have improved water use efficiency. The enhanced water retention and drainage properties allow plants to access water more effectively, which is especially beneficial in areas facing water scarcity.

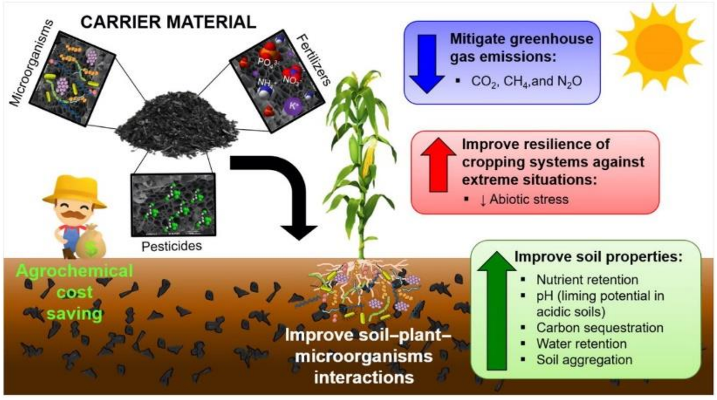

Fig 2: Biochar Carrier Materials

Disadvantages of Biochar

Production Challenges: Variable quality based on feedstock and production methods and energy-intensive production processes.

Initial Cost: Can be expensive to produce and incorporate into soil.

Limited Long-Term Studies: Insufficient long-term data on its effects and permanence.

Feedstock Dependency: Quality and properties depend on the type of feedstock used.

Potential for Nutrient Imbalance: Improper application may lead to nutrient imbalances.

Impact on Local Ecosystems: Unintended consequences on local flora and fauna.

Transportation and Application Logistics: Challenges in transporting and uniformly applying biochar.

Lack of Standardization: Lack of standardized guidelines for production and application.

Phytotoxicity Concerns: Some biochar may exhibit phytotoxic effects if not properly produced.

Perceived Uncertainty: Farmers may be cautious due to limited historical use and understanding.

Conclusion

Biochar, as an emerging soil amendment, represents a revolutionary approach to sustainable agriculture. Its multifaceted benefits, from enhancing soil fertility to contributing to carbon sequestration, position biochar as a valuable tool in the farmer's arsenal for cultivating healthy and resilient soils. As we embrace the potential of biochar, we pave the way for a more sustainable and regenerative future in agriculture.

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Karrikins-The Life Regenerator

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Karrikins is a chemically defined family of plant growth regulators found in smoke of burning plant material. They are remarkable because they can stimulate the seeds of many plant species to germinate. Some plants will grow immediately after bushfires or wildfires because their seeds remain dormant in the soil until a fire generates Karrikins that will bind to soil particles. Then, once the karrikins are washed into the soil by rainfall, they stimulate the seeds to germinate. Karrikins was identified (KAR1: 3-methyl- 2H-furo [2, 3-c] pyran-2- one) in smoke. Karrikins is derived from the word 'karik'- the term used for smoke in 'Noongar Aboriginals' language of South-west Australia. KAR 1 was first compound as the potent germination stimulant present in plant derived smoke.

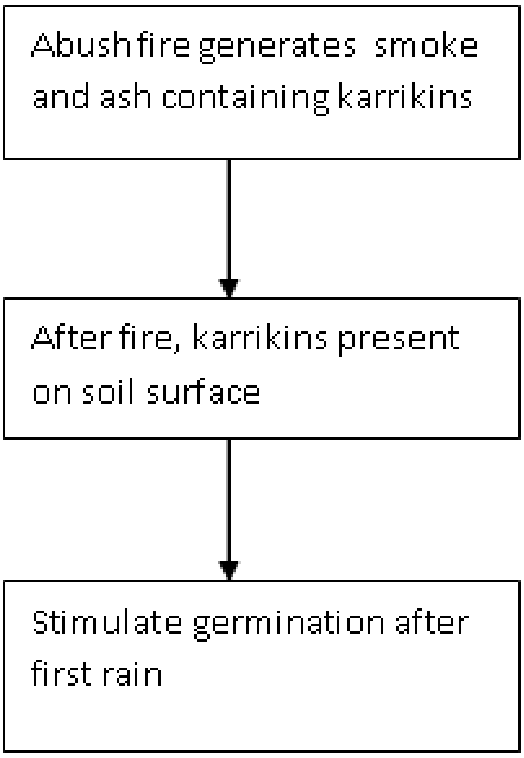

Fig 1: Role of karrikins in revegetation after a fire

Exposure to smoke made from plants has a favorable and stimulating effect on the morphological, physiological, and biochemical characteristics of plants. In contrast to prolonged PDS exposure, short-term plant-derived smoke exposure is more suitable and exhibits a significant effect. By accelerating ABA biosynthesis and inhibiting GA biogenesis, KARs

postponed soybean seed germination. Surprisingly, KARs only prevented soybean seed germination when it was shaded, not in white light or in the dark. The characteristics of karrikins include inhibiting hypocotyl elongation, promoting cotyledon expansion and chlorophyll accumulation, enhancing seedling survival, vigour and photomorphogenesis.

It imitates strigolactones, another type of plant hormone and it also interacts with other phytohormones. While GA is necessary for KAR to increase seed germination, ABA has a detrimental effect on KAR activity. IAA response genes' expression is suppressed by KARs. It is crucial for maintaining seed dormancy in abiotic stresses, preventing germination when under abiotic stress, and promoting germination when the environment is favorable.

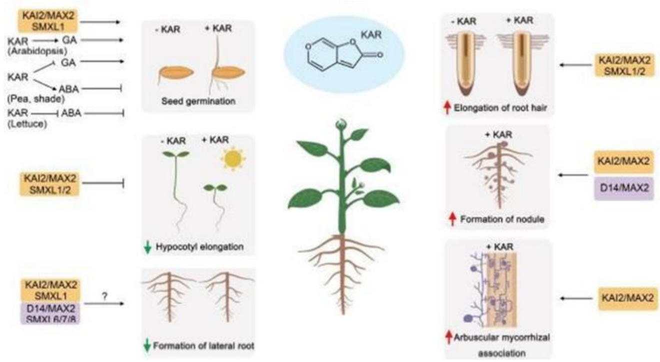

Fig 2: Role of KAR in plant development

Karrikins is emerging as a ubiquitous, multifaceted feature of plant development hence a lot of discovery is required in this hormone. Genomic approaches are the next step forward to uncovering the mode of action. The discovery of Karrikins establishes an exciting nexus between fire ecology, plant evolution and molecular plant physiology.

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Adverse Effects of Pesticides on Human Health

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Pesticides are substances used to control pests and diseases which destroy crops in the field and grains during storage. About 20-30% foods get destroyed by these. So pesticides have become an indispensible input. Pesticides can enter the human body through inhalation of aerosols, dusts and vapours that contain pesticides through oral exposure by consuming food and water and through dermal exposure by direct contact of pesticide with skin.

Pesticide may cause acute and delayed affects in workers who are exposed. Farm workers and their families experience the greatest exposure to agricultural pesticide through direct contact with the chemicals. Children are more susceptible and sensitive to pesticide because they are still developing and have a weaker immune system than adults.

Pesticide exposure can cause a variety of adverse health effects, ranging from simple irritation of the skin and eyes to more severe neurological effects such as memory loss, loss of coordination, reduced visual ability etc. Other possible health effects include asthma, allergies and hypersensitivity, cancer, hormone disruption and problems related with reproduction and fatal development. Other adverse effect can be categorised as:

A. Neurological effects

Pesticides like oragnophosphates, carbamates and some fungicides are neurotoxins and associated with effects on central and peripheral nervous system of animals and humans. When people are exposed to these neurotoxins, they may feel dizzy, confused, reduced coordination and ability to think. These are short term effects. Long term exposure can result in reduced IQ and learning disability, associated with permanent brain damage. Pesticide exposure has also resulted in neurodegenerative disorders such as Parkinson's disease in occupationally exposed person, particularly farmer and gardeners.

B. Reproductive effects

There is elevated risk of reproductive or development effects from direct exposure to some pesticides prior to conception or during prenatal or postnatal period.

Some pesticides have caused fertility problems and increased risk of spontaneous abortion and miscarriage.

Maternal exposure to pesticide used in gardening during early pregnancy has resulted in increased risk of certain birth defects such as cleft lip and palate.

C. Carcinogenic and immune system effects

Some pesticides do change in immune system function (immune toxicity) in animals and humans. A compromised immune system may increase the susceptibility to infectious disease. It may also contribute to development of some cancers. Some studies have shown increased risk of testicular, prostate and cervical cancers and multiple myeloma among those exposed to pesticides through their work. Certain childhood cancers are found associated with parental exposure to pesticides. Pre-conception, prenatal and early childhood exposure to pesticides is associated with childhood brain tumours, leukemia and neuroblastoma. The use of pesticides in home appears to increase the risks of developing these cancers, 2,4-D, a widely used phenoxy herbicide causes cancer.

Effect of pesticide residue

Pesticide residue may be defined as any substance or a mixture of substances in foods, agricultural commodities or animal feeds resulting from the use of pesticides. Pesticides being toxic in nature leave behind their residues when used for pest control. The harmful residues of the pesticides that persists in food commodities and environment have been a cause of concern to everybody. The problem of pesticide residue is more in fruits and vegetables due to their increased and frequent use all throughout the fruiting stage even close to harvest as well as post-harvest application during ripening, transportation and storage. Almost all food materials including cereals, pulses, vegetables, fruits, human diets, honey, milk and milk products and vegetable oils. In a survey conducted by ICMR 51% of our food commodities were found contaminated with pesticide residue and out of these 20% had residue above maximum residue limit (MRT). To control the pesticides residues to minimum level following precautions can be taken:

- Pesticides should be used only when it is absolutely essential. Non-chemical methods should be encouraged.
- Only recommended pesticides should be applied at right time and at prescribed dose.
- Preference should be given to the use of less persistent pesticides.
- Ripe fruit and vegetables should be plucked before pesticide application.
- After pesticide use, the produce should be harvested only after recommended waiting period.
- Pesticide residues on fruits or vegetables can also be reduced by washing with water followed by rubbing and peeling.

Effect on non-target organisms

Bee toxicity: Indiscriminate use of insecticides on field crops has resulted in widespread mortality of honeybees and wild bees which are essential for pollination in crops.

Natural enemies: Parasitoids and predators regulate the population of most insect pests. Unfortunately, many natural enemies are susceptible to a variety of pesticides used in crop production. It results in pest resurgence and outbreak of secondary pests in the treated crop.

Fishes: Pesticides that runoff treated crop and often drain into nearby ecosystem (streams and lakes) and can be highly lethal to fishes and other aquatic biota. Even low concentration pesticide in water may eliminate essential fish foods like insects and other invertebrates. Sub-lethal doses of pesticides may increase susceptibility of fish to disease, starvation and other environmental stress.

Higher concentration may kill fish directly. Insecticides are more toxic to aquatic life than herbicides and fungicides. Application of herbicides to water bodies can kill off plants on which fish depend for their habitat.

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Revolutionizing Agriculture: Enhancing Indoor Vertical Farming Through Smart Lighting

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Vertical farming (VF) is a groundbreaking cultivation method that utilizes vertical space for growing crops. It employs advanced techniques like soilless cultivation, hydroponics, aeroponics, and aquaponics within controlled structures. VF stands out for its resource efficiency, recycling water and nutrients to minimize waste and lower its carbon footprint. This environmentally conscious approach positively impacts sustainability by conserving natural resources, reducing pollution, and lessening waste generation. VF also brings economic benefits by cutting transportation costs and CO_2 emissions in the food supply chain. While not a complete replacement for traditional farming, VF complements existing methods, offering an innovative solution, particularly in urban or limited arable land settings. Integrating VF into agriculture creates a more diverse and resilient food production system, addressing 21st century challenges while respecting established practices.

Plant eco-system

Within the plant Eco-system, Nutrients such as nitrogen, phosphorus, and potassium are needed for plant growth, acting as building blocks for critical chemicals and structures. CO_2 is essential to photosynthesis, the process by which plants convert light energy into chemical energy for development. Adequate CO_2 levels are required for efficient photosynthesis. Light, on the other hand, emerges as the most important component in plant growth, driving photosynthesis and controlling physiological processes such as photomorphogenesis. While study on light has been restricted in comparison to other growth elements, its significance is growing. Understanding the impact of light on agriculture can improve practises, particularly in controlled conditions such as vertical farming. Plants photosynthesise using the visible light spectrum (400-700 nm), which is usually supplied by artificial grow lights. LEDs have grown in popularity due to their low cost, small form, and wide range of wavelengths. Light intensity, quality, and duration (photoperiod) are key dimensions influencing plant growth.

Significance of Light and Spectrum

The appropriate light intensity and spectrum are critical for a good harvest since they have a direct impact on plant growth, development, and output. Plants absorb light mostly in the blue and red spectrums, which is necessary for photosynthesis. Photosynthesis is hampered if the light lacks these efficient wavelengths, leading in lower growth and production. The optimal light intensity, as measured by Photosynthetically active radiation (PAR), is crucial for a variety of outcomes:

Low Light Intensity: Insufficient energy for photosynthesis leads to leggy growth, small leaves, and slow development, impacting flowering and fruiting.

Optimal Light Intensity: Providing the right PAR range ensures maximum photosynthetic capacity, fostering vigorous growth, healthy foliage and higher yields for fruiting plants.

Excessive Light Intensity: Too much light can stress plants, causing photoinhibition and damage to photosynthetic machinery.

Striking a balance between spectrum and intensity is vital across various farming methods, from traditional outdoor farming to advanced systems like vertical farming, to tailor lighting conditions to crop needs, resulting in healthier, more productive plants and superior harvests.

Optimizing Blue and Red Light in Horticulture

Only 2% of greenhouse lighting in the United States employed energy-saving LED systems in 2017, with the majority relying on less efficient high-pressure sodium (HPS) and metal halide (MH) lamps. Annual energy use for supplemental lighting in greenhouses in the United States was 588 gigatonne-hours (GWh), or 6.1 trillion British thermal units (tBtu). If the remaining 98% switched to LEDs overnight, annual consumption would fall to 416

GWh, or 4.3 tBtu of energy—an impressive 29% reduction in energy usage. This transition not only highlights the huge energy savings potential of LED lighting in horticulture, but it also results in significant cost savings of roughly $18 million, making it both environmentally and economically beneficial for the greenhouse industry.

Blue light (400-500 nm) is essential in horticulture because it shortens internode length, resulting in a bushier and more compact plant structure. This promotes robust and space-efficient growth while also increasing carbon dioxide intake via leaf stomatal apparatus opening. Blue light aligns with the absorption range of chlorophyll, optimising energy production during photosynthesis. Aside from physiological benefits, blue light influences a plant's circadian rhythm, which contributes to overall health and nutrient richness.

Red light (630-660 nm) is essential for stem growth, leaf expansion, and the regulation of key plant processes such as flowering and dormancy. It is well-known for promoting rapid growth, allowing for tall and vigorous plant development in a short period of time. Growers can manipulate flowering timing, manage dormancy, and stimulate seed germination by using red light to control growth stages. Red light is a valuable resource for achieving specific cultivation goals and schedules, making it an important component of horticultural lighting strategies for desired plant characteristics and yields.

Plant Energy Conversion Mechanism

Photosynthesis, which is essential for plant growth, consists of approximately 23 intricate steps that convert low-energy inputs into high-energy carbohydrates. In the visible light spectrum, the efficiency metric, which measures the number of photons required to fix one CO2 molecule, is around ten. Individual steps operate at approximately 95% efficiency, with a theoretical maximum efficiency of 30%. Overall efficiency is limited to 30% due to cumulative effects and limiting factors such as environmental conditions. Photosynthesis converts a fraction of the incoming light energy into essential carbohydrates, despite its intricate efficiency at each step. Understanding these complexities is essential for improving plant productivity as well as addressing global food and energy challenges.

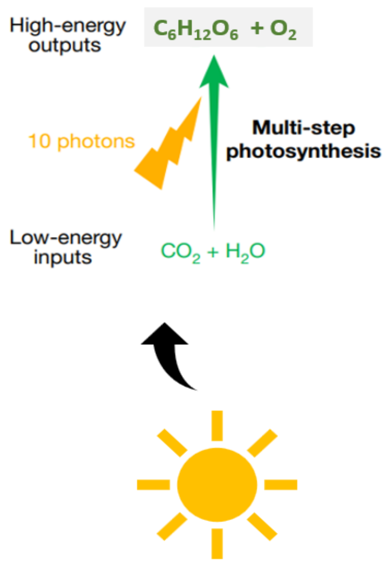

Photo Morphology: Light's Influence on Plant Shape and Colour

Light has both direct and indirect effects on plants, according to a 2018 study by Pattison and colleagues using the Red Salad Bowl lettuce cultivar. Their findings revealed that light intensity has a significant impact on plant responses, particularly the synthesis of anthocyanin pigments, which provide a protective red colour to the leaves. Insufficient light triggered anthocyanin synthesis when the photosynthetic photon flux density (PPFD) was low (equivalent to 10% of full sunlight). Increasing the PPFD to 25% resulted in anthocyanin synthesis, demonstrating the plant's response to changing light intensity under potentially stressful conditions.

Leaf expansion is influenced by the wavelength or colour of light. Leaf expansion decreases as the proportion of blue light increases, as seen in transitions from warm to neutral to cool white light. This suggests that different light wavelengths have an effect on plant growth and morphology. The intensity and wavelength of light have an impact on plant responses and growth patterns.

IoT-Enabled Smart Lighting Control Strategy

The integration of Internet of Things (IoT) technology in greenhouse or indoor farming settings to optimise and control the use of artificial lighting is referred to as an IoT-Enabled Smart Lighting Control Strategy. This novel approach makes use of real-time data, predictive models, and intelligent algorithms to manage the supplemental lighting provided to plants.

The following are possible key components of IoT-enabled smart lighting control strategies:

1. Probabilistic Models: Using advanced models to forecast natural sunlight availability, such as Markov-based sunlight prediction models. These models aid in anticipating periods of low natural light, allowing for intelligent supplemental lighting adjustment.

2. Plant-Specific Requirements: Consider the specific light requirements of the plants being grown. Light intensity, duration, and spectrum requirements vary by crop. IoT technology enables customization based on these specific needs, optimising plant growth and energy consumption.

3. Variable Electricity Pricing Profiles: Considering fluctuating electricity pricing profiles. The strategy aims to reduce overall energy costs by aligning lighting schedules with times of lower electricity costs.

4. Real-Time Monitoring: Continuously monitoring environmental conditions within the greenhouse using sensors and IoT devices. This includes things like lighting, temperature, and humidity. Real-time data allows for dynamic lighting strategy adjustments based on current conditions.

5. Energy Efficiency: Improving energy efficiency is the primary goal of an IoT-enabled smart lighting control strategy. It reduces overall energy consumption and associated costs by intelligently coordinating artificial lighting with natural sunlight conditions and adapting to the specific needs of the plants.

6. Experimental Studies: To validate the effectiveness of these strategies in real-world conditions, researchers frequently conduct experimental studies. In these studies, IoT-enabled lighting controls are implemented in controlled environments and the impact on plant growth, energy consumption, and cost savings is measured.

Overall, IoT-enabled smart lighting control strategies represent a forward-thinking approach to environmentally friendly and financially viable greenhouse operations. Growers can improve energy efficiency, lower operational costs, and contribute to more environmentally conscious and productive agricultural practises by leveraging the power of IoT technology.

Conclusion

Vertical farming (VF) uses hydroponics, aeroponics, and aquaponics to revolutionise crop cultivation in three dimensions. VF conserves resources, promotes sustainability, and supplements traditional farming methods. It excels at lighting control, which is essential for photosynthesis, flowering, and fruiting. With LEDs, lighting technology advanced from chemical-fuel to efficient electric discharge lamps. LEDs, which are small and energy-efficient, have tripled their efficacy in the last decade, making indoor farming more sustainable. Blue light promotes growth and nutrient uptake, whereas red light controls flowering and dormancy. The amount of light, as measured by PPFD, influences pigment synthesis and leaf expansion. Greenhouse lighting is optimised using advanced technologies and IoT sensors, saving energy. In the face of evolving challenges, smart lighting in VF promises a sustainable agriculture future by conserving energy and ensuring productivity.

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Revolutionizing Agriculture: The Power of Nano-clay Polymer Composites

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In the face of mounting challenges in modern agriculture, ranging from escalating soil erosion rates and water scarcity issues to the detrimental effects of pesticide runoff, innovative solutions are paramount to ensure both food security and environmental sustainability (Krzemińska et al., 2023). One groundbreaking avenue that has emerged is the utilization of nano-clay polymer composites. These composites, meticulously enginee=red at the nanoscale, hold immense promise in addressing these pressing concerns. Recent data underscores the urgency of action: soil degradation affects over one-third of the world's arable land (globally, at least 33% of all croplands are moderately or highly degraded, Davis et al., 2023)), water scarcity threatens the livelihoods of billions, and pesticide runoff continues to compromise aquatic ecosystems (Ezeonyejiaku, 2023). The fusion of nano-clay and polymers to form these composites offers a glimmer of hope in combating these issues, as they exhibit unparalleled potential to enhance soil structure, elevate water retention capabilities, and mitigate the ecological impact of chemical usage. Against this backdrop, the incorporation of nanoclay polymer composites stands as a testament to human ingenuity, holding the key to not only revolutionizing agricultural paradigms but also fortifying the very foundation of our planet's sustenance.

Basics of Nano-clay Polymer Composites

Nano-clay polymer composites are hybrid materials formed by integrating nanoscale clay particles into a polymer matrix. These composites combine the unique properties of both components to create a material with enhanced mechanical, thermal, barrier, and flame-retardant characteristics. The nano-clay particles are dispersed at the nanometer scale within the polymer, creating a synergistic effect that improves the overall performance and functionality of the composite material. This integration results in a versatile material with a wide range of potential applications across various industries, including aerospace, automotive, packaging, construction, and more. NCPC mostly synthesised with three methods i.e., Solution blending, mix blending and *in-situ* polymerization (Guo et al., 2018). For agricultural use solution blending method was followed for NCPC synthesis in laboratory process as described by Liang and Liu, (2007). NCPC has potential application in agriculture in terms of nutrition as well as protection due to their size, high surface-to-volume ratio and unique properties. Polymers display controlled release of nutrients and serves as carriers for nutrients as well as pesticide ingredients, water holding capacity, fluorescence (QDs) or photo catalytic degradation (metal oxide NPs) that has biotechnological applications in sensor development, agrochemical degradation and soil remediation.

Fig 1: Nano-Clay Polymer Composites

Enhancing Soil Structure and Water Retention:

Research has unveiled the transformative potential of nano-clay polymer composites in revolutionizing soil management and conservation practices. By introducing these composites into soil, their capacity to enhance soil structure and counteract erosion becomes evident. The nanoclay particles, with their nano-sized dimensions, intercalate within soil particles, fortifying their structural integrity and increasing their stability against erosive forces. This results in significantly reduced soil erosion rates, preserving valuable topsoil and mitigating the environmental consequences of erosion (Syakir et al., 2016). Moreover, the water retention properties of nano-clay polymer composites (holds water moisture about 50% up to 60 days) offer a game-changing solution to water scarcity challenges in agriculture (Saurabh et al., 2019). These composites effectively create a reservoir-like environment within the soil matrix. By absorbing and holding water molecules, they increase soil moisture content, thereby extending the duration between irrigation cycles. This not only conserves water but also optimizes plant hydration, promoting healthier growth and minimizing the energy and resource demands associated with frequent irrigation practices. As these pioneering applications continue to yield promising results, the marriage of nanotechnology and soil science holds the promise of transforming how we nurture and protect our vital soil resources for generations to come.

Fig 2: water swelling capacity of Nano Clay Polymer Composites after 24hrs

Smart Delivery of Nutrients and Pesticides:

Nanoclay polymer composites have emerged as a groundbreaking solution for the intelligent and controlled delivery of nutrients and pesticides in agriculture. These composites serve as carriers, encapsulating nutrients and pesticides within their intricate structure and facilitating their gradual and targeted release into the soil (The coated fertilizer exhibited a much slower release and achieved a cumulative release ratio below 75 % after 30 d in soil) (Dou et al., 2023). This controlled release mechanism offers a multitude of benefits, including enhanced nutrient utilization by crops and a reduction in the environmental footprint of pesticide application. The controlled release of nutrients addresses a longstanding challenge in conventional fertilization practices. By releasing nutrients over an extended period, these composites provide a continuous supply that aligns with the crop's growth stages and demands. This not only boosts nutrient absorption efficiency but also curtails the excess use of fertilizers, subsequently minimizing nutrient leaching and runoff, which can lead to pollution of water bodies.

Furthermore, this innovative approach to pesticide delivery holds tremendous potential for sustainable pest management. The gradual release of pesticides from the nano-clay polymer composites ensures that crops receive consistent protection against pests over time. This diminishes the need for frequent reapplication of pesticides, reducing the risk of pesticide resistance development and limiting chemical exposure in the environment. As a result, this controlled delivery system contributes to healthier crop growth while mitigating the adverse ecological effects associated with excessive pesticide application (Perera et al., 2023).

Mitigating the Effects of Climate Change:

By enhancing soil health, these composites promote carbon sequestration and mitigate greenhouse gas emissions. The improved soil structure and reduced erosion rates brought about by nano-clay integration create an environment conducive to microbial activity, fostering organic matter decomposition and carbon storage within the soil. The reduction in chemical usage translates to diminished emissions of nitrous oxide, a potent greenhouse gas released from fertilizers, and a decrease in the overall ecological footprint of agriculture (Kothari et al., 2022). In this way, nano-clay polymer composites offer a practical pathway towards more sustainable farming practices that align with climate goals.

Challenges and Future Prospects:

While nano-clay polymer composites hold immense promise for revolutionizing various sectors, including agriculture, their widespread adoption does encounter certain challenges that warrant consideration. One such challenge pertains to the cost of production, as the synthesis and incorporation of nano-clay particles can be resource-intensive. Additionally, ensuring the scalability of production processes to meet agricultural demands is a key concern. However, ongoing research and development efforts are actively addressing these challenges to render nano-clay polymer composites more accessible and practical. Scientists are exploring innovative synthesis methods, efficient encapsulation techniques, and sustainable sourcing of raw materials to optimize production costs. Moreover, collaborative endeavours are underway to fine-tune formulations and application methods, ensuring that the benefits of these composites can be harnessed across diverse agricultural contexts. The future of nano-clay polymer composites holds significant promise. As research advancements lead to cost-effective and scalable production, these composites are likely to become integral tools for sustainable agriculture, offering solutions to soil degradation, resource inefficiency, and climate resilience. Beyond agriculture, the adaptability of nano-clay polymer composites suggests potential applications in fields such as environmental remediation, packaging, and even biomedical technologies. The trajectory of this technology underscores the dynamic interplay between scientific innovation and practical solutions, poised to shape a more sustainable and resilient future across a spectrum of industries.

Conclusions

In conclusion, nano-clay polymer composites stand as a example of innovation in agriculture, offering transformative solutions that transcend traditional farming practices. Their ability to bolster soil health, conserve resources, mitigate environmental impacts, and enhance crop resilience makes them pivotal tools for sustainable agriculture. As we navigate the challenges of feeding a growing global population while confronting climate change, these composites represent a promising pathway towards resilient and eco-conscious farming. It is imperative that we remain vigilant about advancements in this field and consider the profound benefits of integrating such innovative technologies into our agricultural practices. In doing so, we can cultivate not only healthier crops but also a more sustainable and harmonious relationship with the planet.

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Bioretention Systems for Managing Urban Stormwater

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The world's population has surpassed 8 billion, with urbanization being a dominant trend. In 1950, urban population was only 33% of the total, but it has steadily grown, reaching 55% today. Projections indicate it could be 66% by 2050. In 1950, urban population was 746 million, constituting 33% of the total. Over time, the urban population has steadily increased, surpassing rural in the late 2000s. Projections suggest it will reach 66% by 2050. But urbanization has dominant impact on hydrologic scale for the urbanized areas.

Impacts of Urbanization on Hydrology

1. Increase in Water Demand

The growing urban population intensifies the demand for freshwater, which leads to increased withdrawals from surface as well as groundwater sources located in the urban areas.

2. Wastewater Load

Urban expansion results in higher wastewater loading, which invariably challenges the existing treatment and disposal systems and at the same time there is a chance of contamination for the existing freshwater bodies.

3. Solid Waste Generation

Urban development generates more solid waste, contributing to the growing issue of waste management and disposal.

4. Altered Water Flow

As there is increase in impervious surfaces over the time period, it alters natural water flow, causing increased runoff rates, reduced groundwater recharge, and congestion during storms leading to the problem of stormwater disposal.

5. Environmental Impacts

Changes in hydrology contribute to downstream flooding, streambank erosion, and declining water quality among some of the major impacts.

Low Impact Development (LID) as a Solution

To counteract these impacts of urbanization, Low Impact Development (LID) emerged in the early 1990s. LID, or otherwise known as sustainable urban drainage, integrates land planning and engineering to implement small-scale hydrologic controls with integrated pollutant treatment. Among various forms of LID, Bioretention is one widely adopted, aiming to manage runoff, enhance surface water quality, improve groundwater recharge, and enhance community aesthetics.

Bioretention Systems

Bioretention systems which is an integral components of sustainable urban stormwater management, function as purposefully designed landscaped depressions. Which primarily serves as sponges for runoff from impermeable surfaces, such as roads and rooftops and these systems play a crucial role in emulating natural hydrologic processes.

Components of Bioretention Systems

1. Vegetation Layer

- The main purpose is the evapotranspiration of the congested stormwater retained in the system.

- It functions as gradual absorptive area of stormwater.

2. Mulch Layer

- It reduces incoming stormwater velocity which helps in increasing infiltration opportunity time.

- It has also the function to retains debris and soil particles from going into soil media.

3. Soil Layer

- It provides structural support to plants.

- Along with this facilitates stormwater infiltration with filtration.

4. Media Layer

- This is one of the key layers for runoff reduction and pollutant removal sometimes known as the heart of the system.

- It also functions as filter for debris, particles, and pollutants from runoff.

5. Underdrain

- This layer is not present for all the systems. But it is included only when soil permeability is low.

6. Hydraulic Control Structures

- Facilitates water conveyance to and from the system.

Function of Bioretention Systems

1. Hydrologic Performances

Some of the parameters on which hydrologic performances depends are given below

a. Media Porosity and Storage

- Pore space and storage depend on media texture.

- This links between soil texture, porosity, wilting point, and field capacity.

b. Infiltration and Conductivity

- Media selection is a crucial aspect for adequate infiltration.

- For majority of systems it is expected to have at least 75% sand with minimal fines.

c. Evapotranspiration

- Contribution of evapotranspiration to water balance varies for different systems as species of plant may vary.

- Depends on climate, vegetation, media, and system parameters.

2. Water Quality Performance

Some of the parameters on which water quality performances depends are given below

a. Media Reactivity

- Media as it is heart of the system, selection of media is crucial for removing urban runoff contaminants.

- Reactive minerals are very effective in removing harmful elements.

b. Evapotranspiration and Soil Wetting/Drying

- Wetting/drying cycles and inter-event durations also impacts water quality of the system.

- Interevent dry periods are very much crucial for nutrient capture.

c. Plant Uptake

- Plant uptake directly contributes to solute removal.

- Species-specific contribution to pollutant removal, especially nutrients can be done with proper planning.

d. Microorganisms

- Microorganisms also impact nutrient retention.

- Interactions with vegetation is very critical for nutrient cycles and water quality.

Selected Comprehensive Analysis of Bioretention Systems

Hydrologic Performance of Bioretention Systems Based on Different Media Depths

Li *et al.* (2009) conducted an experiment to investigate the hydrologic performance of six distinct bioretention cells located in various regions, aiming to address the challenges posed by urban impervious surfaces. The cells vary in size, media depth, and monitoring duration, providing a comprehensive analysis of their effectiveness. The research utilizes consistent monitoring methods across all cells, including direct measurement of rainfall intensity, inflow monitoring in Maryland, and application of the SCS curve number method in Greensboro. The study introduces key metrics, such as peak flow rate ratio (R_{peak}), peak discharge time span ratio (R_{delay}), and effluent/influent volume ratio (f_V24), to assess the restoration of hydrologic conditions. Results show that bioretention cells effectively mitigate post-development hydrology, demonstrating peak flow reduction and enhanced infiltration. However, their performance diminishes under more extreme precipitation events, and deeper media depths (>0.9 m) tend to promote more infiltration and evapotranspiration.

Bioretention System Comparison for Different Media Layers

As media layers are heart of the bioretention system, Yang *et al.* (2020) explores the impact of filler layer structure on hydrologic performance and pollutant removal efficiency in bioretention systems with different media layer. The experiment was setup with three different layers, filler layer, transition layer and drainage layer. Three configurations

1. All Three Layers,

2. Without Transition Layer,

3. Without Drainage Layer were tested using synthetic stormwater.

Lab-scale bioretention units were constructed, and runoff control effects were evaluated under different rainfall intensities. Results indicate that the presence of a 200 mm drainage layer plays a crucial role in runoff control. As rainfall intensity increases, differences in runoff reduction rates between configurations decrease, emphasizing the importance of the filter layer in stormwater runoff reduction.

Water Quality Performances of Bioretention Systems with Different Media Depths

As water is drained through the system so, to examining conventionally drained bioretention cells in Nashville, Brown *et al.* (2013) conducted this study, which focuses on the influence of previous events on outflow concentrations. Flow-weighted composite samples from consecutive events during different seasons reveal insights into cumulative pollutant loads, seasonal impacts, and the role of consecutive events. Results show that the 0.9-m media depth cells release approximately twice the load of dissolved pollutants compared to the 0.6-m media depth cells. The study concludes that while bioretention cells sufficiently reduce pollutant loads, deeper media depths exhibit varying water quality performances influenced by antecedent conditions.

Water Quality Performance Measurement Using Bioretention Cells

As the cells are meant to protect the water from harmful elements. To assess this an experiment was conducted at the University of Maryland by Davis (2007), which assesses water quality improvements in parking lot stormwater runoff through standard bioretention and anoxic sump-incorporated systems. Twelve stormwater events were monitored for TSS, TP, NO3-N, lead, copper, and zinc concentrations. Results demonstrate overall composite median percent removals for pollutants, with mass removals consistently greater than concentration-based removals due to flow attenuation. Water quality leaving both cells was consistently good, with future research recommendations focusing on computational models, system maintenance, cost considerations, and life cycle assessments.

So, in conclusion it is found that the bioretention systems are effective way to counter the bad effect of urbanisation on the hydrologic regime on the urbanized area.

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Microbial Synthesis of Nanoparticles and Its Application in Aquaculture

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The science and technology of creating nanoparticles and manufacturing machines which have sizes within the range of nanometre is called Nanotechnology. Nanotechnology involves creating and manipulating organic and inorganic matter at the nanoscale. The use of NP-based antimicrobials, vaccines against many viral pathogens is a developing field in fish medicine research (Shaalan *et al.*, 2016). NPs have gained much interest as a specific and sensitive tool for diagnosis of bacterial, fungal and viral diseases in aquaculture. Nanotechnology has become an extensive field of research due to the unique properties of nanoparticles (NPs), which enable novel applications in the field of medicine, including antimicrobial effects, diagnostics, vaccination, drug and gene delivery (Aulenta *et al.*, 2003).

Table 1: Types of nanoparticles and its application.

Types of nanoparticles	Structure	Application
Nanospheres	Spherical shaped	Drug delivery, tissue regeneration
Nanocapsules	Shell and core combination	Controlled drug delivery
Carbon nanotubes	Cylindrical tubes	Drug delivery, anti-cancer
Liposome	Lipid bi-layer globules	Drug delivery for hydrophobic and hydrophilic drugs
Dendrimers	Highly branched ends and central core	Delivery system, tissue engineering, antimicrobials
Polymeric nanoparticles	Polymers as chitosan	Delivery system, tissue regeneration

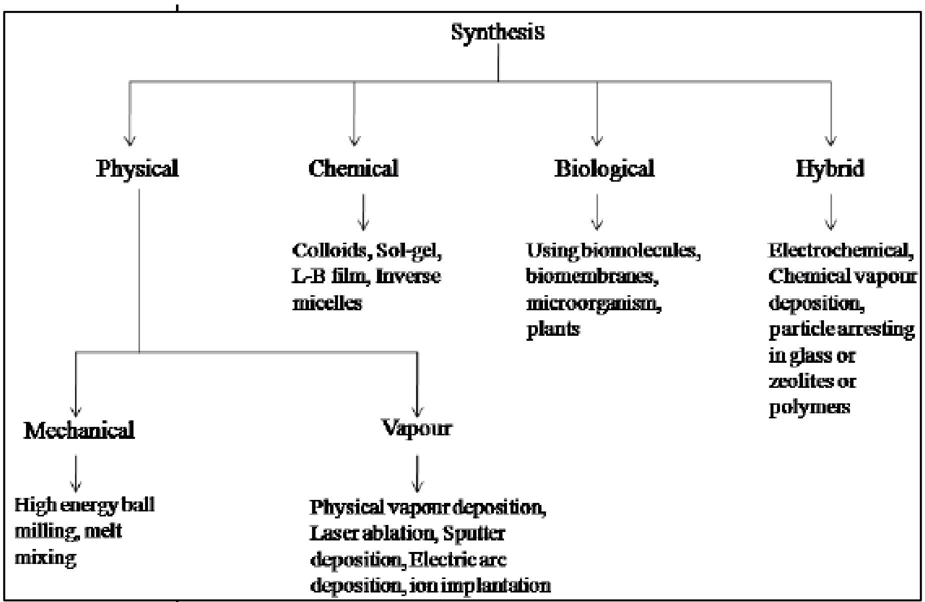

Fig 1: Different methods of synthesis of nanoparticles (Aher and Avinash, 2013)

Synthesis of nanoparticles

Synthesis of nanoparticles using microorganisms: Bacteria

There are two methods of synthesis of nanoparticles by bacteria:

- **i.** Intracellular: inside the cell in cytoplasm
- **ii.** Extracellular: outside the cell on the surface or between the cells inside a colony

Intracellular Synthesis of Nanoparticles

This method includes mainly the accumulation of the particles called as bioaccumulation. In order to release the intracellularly synthesized nanoparticles, additional processing steps such as ultrasound treatment or reaction with suitable detergents are required. *Bacillus subtillis* 168 reduced water-soluble Auric to Aurous producing octahedral morphology inside the cell walls in the dimension of 5-25 nm (Alsamhary, 2020). In Fe (III) reducing bacterium Geobacterferrireducens, gold was precipitated intracellularly in periplasmic space. Silver-based single crystals such as equilateral triangles and hexagons with particle sizes up to 200 nm in periplasmic space of the bacterium were produced by

Pseudomonas stutzeri AG259, a silver mine bacterium (Klaus *et al.*, 1999). It has been believed that the organic matrix contains silver-binding proteins that provide amino acid moieties, which serve as nucleation sites for the formation of silver nanoparticles.

Extracellular Synthesis of Nanoparticles

This method includes bio mineralization, bio sorption or precipitation. When the cell wall reductive enzymes or soluble secreted enzymes are involved in the reductive process of metal ions then the metal nanoparticles are extracellularly secreted (Narayanan and Sakthivel, 2010). With the change in pH of the solution, various shapes and sizes were formed. The culture supernatants of Enterobactericeae like *Klebsiella pneumonia*, *E.coli*, *Enterobacter cloaceae* rapidly synthesize silver nanoparticles by reducing Ag + to Ag. Titanium nanoparticles of spherical aggregates of 40–60 nm were produced extracellularly using *Lactobacillus sp.* at room temperature (Prakash *et al.*, 2013).

Synthesis of nanoparticles using microorganisms: Fungi

Synthesis of gold nanoparticles

Extracellularly gold nanoparticles are synthesised using the fungus *Fusarium oxysporum.* Incubation of the fungus mycelium with Auric chloride solution produces gold nanoparticles in 60 min (Thakker *et al.*, 2013). Gold nanoparticles were characterized by UV-Visible spectroscopy and particle size analysis. The particles synthesized were of 22 nm sized, capped by proteins and showed antimicrobial activity against *Pseudomonas sp.*

Synthesis of silver nanoparticles

AgNPs were synthesised using the fungus *Arthroderma fulvum* Strain HT77 which was cultivated in potato dextrose broth and had been inoculated with. The flasks were incubated at 28°C and 140 rpm for 7 days. After incubation, fungal biomass was separated by filtration, washed with sterile distilled water to remove the traces of culture media components, resuspended in 100 ml distilled water, incubated at 28°C for 24 hours, and then filtered. Silver nitrate ($AgNO_3$) was added to the filtrate to promote the formation of AgNPs. The ratio of cell filtrate to $AgNO_3$ was kept at 1:9 (v/v), and the reaction mixture was incubated at 28°C for 48 hours. Controls (without the addition of $AgNO_3$) were incubated under the same conditions. Color change in the reaction mixture was the initial indicator of the formation of AgNPs. When the color changed, 3 ml of the reaction mixture was removed to measure its absorbance using a UV-visible spectrophotometer. The presence of AgNPs was confirmed by X-ray diffraction and AgNPs were isolated by centrifugation cells (Narayanan and Sakthivel, 2010).

Mechanisms of antimicrobial activity of the metal NPs

Entering the cell

Attachment of the nanometer range metallic ions with the cell through trans-membrane protein is the initial step of the antibacterial mechanism. The initial interaction of ions with the cell surface of microbes starts with the attraction of positively charged silver with negatively charged microbial cells, thus leading to the development of several pores in the cell membrane and outflow of intracellular materials. The next step is to create structural changes in the cell membrane and obstructing its transport channels (Dutta *et al.*, 2012); this whole process depends on the size.

Reactive Oxidative Species Generation

For NPs antibacterial effectiveness, the formation of ROS plays a critical role. ROS contains ephemeral oxidants, like superoxide radicals (O'^{2}), hydrogen peroxide (H_20_2), hydroxyl radicals (OH^4) and singlet oxygen (O^{-2}) (Raffi *et al.*, 2008; Baek and An, 2011). ROS can result in damage to the peptidoglycans of cell membranes, DNA, mRNA, proteins, and ribosomes because of its high reactivity (Pelgrift *et al.*, 2013). Translation, transcription, the electron transport chain, and enzymatic activity are also inhibited by ROS (Raffi *et al.*, 2008).

Protein Inactivation and DNA Destruction:

To deactivate the function of enzymes, metal atoms attach with thiol groups of enzymes. It is observed that the bonding of hydrogen between two anti parallel strands of DNA is also disturbed by metal ion attachment, which ultimately destructs the molecule of DNA. The true metal ions also show a tendency to attach to DNA after they get inside the cell, but it is still under investigation (Jung *et al.*, 2008).

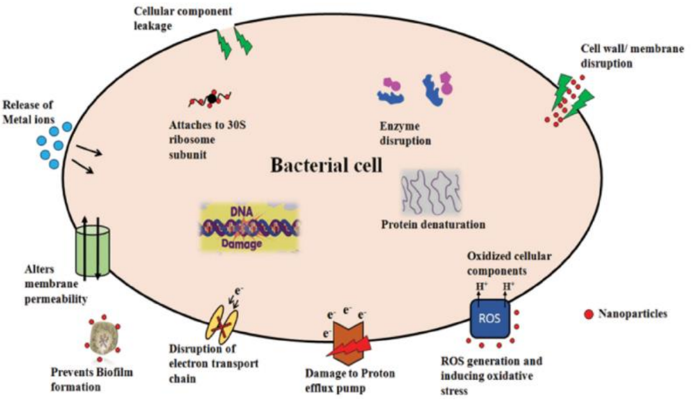

Fig 2: Antimicrobial activities of nanoparticles (Wang *et al.*, 2017)

Nanoparticles as Antimicrobials in Fish Medicine

The utilization of NPs as alternative antimicrobials to combat emergence of microbial resistance to antibiotics in aquaculture has been investigated. Metal NPs have shown high antimicrobial activity against bacteria, fungi and viruses.

Silver nanoparticles (Ag-NPs): Ag-NPs demonstrate high antibacterial efficacy against multi-drug resistant bacteria isolates, antibacterial activity against *S. aureus* and *E. tarda*, and anti-cyanobacterial activity towards *Anabaena* and *Oscillatoria* species (Prakash *et al.*, 2013). As an antifungal agent, Ag-NPs exhibited high inhibitory effects against *Candida* species, similar to the commercial antifungal Amphotericin B. Ag-NPs are active against influenza A virus.

Gold Nanoparticles (Au-NPs): Au-NPs can interact with biological proteins and non-proteins, e.g. LPS, and have biological functions. Au-NPs supported on zeolite exhibited bactericidal effects against *E. coli* and *S. typhi*. Functionalized Au-NPs inhibited the growth of MDR bacterial isolates. Au-NPs made by 'green' synthesis showed antibacterial activity against fish bacterial isolate. There are three pathways along which Au-NPs exert their antibacterial effects (Thakker *et al.*, 2013).

The first pathway is via interfering with oxidative phosphorylation process with changing the potential of bacterial cell membrane; this leads to decrease in the activity of F-Type ATP synthase with a net decrease in ATP synthesis and metabolism.

The second pathway is interference with binding of tRNA to the two ribosome subunits.

The third pathway is achieved through enhancing chemotaxis.

Fungicidal activity against *Candida* species was reported for Au-NPs. Their efficacy was size-dependent, with smaller Au-NPs having higher antifungal effects (Gutiérrez, *et al.*, 2018).

Zinc Oxide Nanoparticles (ZnO-NPs): ZnO-NPs have drawn much attention due to their antibacterial and antifungal effects. The antibacterial activity derives from the particles damage to the bacterial cell membrane, which makes cytoplasmic contents leak from the cell. In the field of fish medicine, ZnO-NPs can inhibit the growth of *A. hydrophila, E. tarda, Flavobacterium branchiophilum, Citrobacter spp., S. aureus, Vibrio, Bacillus cereus* and *Pseudomonas aeruginosa*. Ramamoorthy *et al* investigated the antibacterial effects of ZnO-NPs against the pathogenic *V. harveyi* and observed higher bactericidal effects of NPs compared to bulk ZnO (Ramamoorthy *et al.*, 2013).

Conclusion and Future Directions

It has been summarized the current applications of NPs in aquaculture. There are, however, many research gaps in the field of nanotechnology applications in aquaculture. Different forms of NPs like nanocapsule, liposome, dendrimer and nanotubes could theoretically have applicability in fish diseases research. The antifungal and antiviral effects of NPs against fish diseases have yet to be explored. Given the demonstrated potential of NPs there are needs for more targeted investigations of their application in many fish medicine research topics, to promote more efficient fish disease diagnostics and therapy, to meet the ever-growing aquatic animal health demand.

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Smart Agriculture: Fact or Fiction

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No life can exist without food, and both the necessity for food and the need for farmers are always growing in our daily lives. The farmers use a variety of techniques to produce nutrient-rich food for us, but they encounter several difficulties from seeding to selling. Additionally, the government is making efforts to lessen these issues. One approach to get out of the crisis is through smart farming. Modern technology advancements have an influence on many aspects of human life, including agriculture. The idea of sophisticated farm management is relatively new, and it is called smart farming. Utilising different tools and technologies in agriculture to streamline and automate repetitive tasks is known as "smart farming.". With the proliferation of the Internet and mobile devices, these technologies are now accessible to small private farms in addition to huge corporations. Due to the fact that agriculture accounts for 60% to 70% of India's GDP, agriculture is important for the growth of food production. Unintentional usage of groundwater is hastening its daily decline. A significant turning point in the development of technology is the Internet of Things (IOT). IOT is highly essential in many industries, including agriculture, which has the potential to feed billions of people in the future. There is no need to worry about scheduling irrigation according to crop or soil conditions because the entire system is microcontroller based and can be handled from a distance via wireless communication. The country has a lot of land used for agriculture.

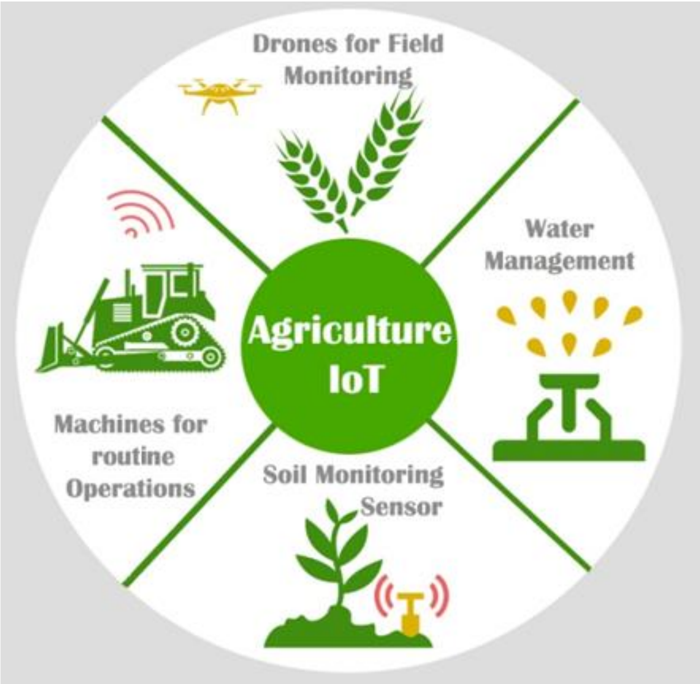
Smart agriculture, sometimes referred to as precision agriculture or digital agriculture, is a cutting-edge farming method that optimises many areas of agricultural output by using cutting-edge technology and data-driven methodologies. It strives to increase agricultural operations' productivity, sustainability, and efficiency while reducing resource waste and environmental effect.

Key components of smart agriculture include

1. **Data collection:** Gathering information on soil conditions, crop health, weather patterns, and other pertinent characteristics from a variety of sources, including sensors, drones, satellites, and weather stations.
2. **Data Analysis**: Processing and interpreting the gathered data using sophisticated analytics and machine learning techniques. Making educated decisions about planting, irrigation, fertilisation, pest management, and harvesting is made easier as a result.
3. **Automation**: Utilising automation technology, such as robotic harvesters, autonomous tractors, and automated irrigation systems, to decrease the need for labour and increase operational effectiveness.
4. **Precision Farming**: Adjusting agricultural methods in detail in accordance with the data and analyses. This entails applying fertilisers and insecticides at varying rates, as well as altering planting and irrigation to suit particular field conditions.
5. **IoT (Internet of Things**): Establishing a network connection between various farm equipment and systems to allow for the real-time monitoring and management of agricultural activities.
6. **Remote Monitoring**: Using remote sensing technology to monitor ambient conditions, animal health, agricultural growth, and environmental factors.
7. **Big Data**: Managing and studying huge amounts of agricultural data in order to learn more and make better decisions. Sustainability: Supporting environmentally friendly agricultural practises by maximising the use of resources (such as water and fertiliser), lowering waste, and minimising the impact of farming activities on the environment.
8. **Farm Management Software**: implementing technological solutions that assist farmers in more

efficiently planning, monitoring, and managing their operations.

9. **Market Access**: Making use of technology to link farmers with markets, consumers, and supply chains, allowing for the effective distribution of agricultural goods.



Source: https://www.javatpoint.com/iot-smart-agriculture-domain

Advantages and disadvantages of smart agriculture

Smart agriculture, like any technological advancement, comes with its own set of advantages and disadvantages. some of the key pros and cons:

Advantages of smart agriculture

1. **Increased Productivity**: By utilising smart agricultural technology, farmers may better manage their animals and increase crop harvests. This might aid in supplying food to the expanding world population.
2. **Resource Efficiency**: Utilising data-driven insights to apply resources like water, fertiliser, and insecticides precisely saves waste and decreases production costs.
3. **Improved Decision-Making**: Farmers can make better choices about planting, harvesting, and pest management thanks to data analytics and real-time monitoring.
4. **Environmental Benefits**: Reduced resource waste and more environmentally friendly agricultural methods can lessen agriculture's negative environmental effects, such as soil erosion and water pollution.
5. **Labor Savings**: Smart agriculture uses automation and robots to eliminate the need for physical labour, which may be especially advantageous in areas with a labour shortage.
6. **Risk Mitigation**: Farmers may reduce risks and costs by using catastrophe monitoring, weather forecasts, and early crop disease identification.
7. **Remote Management**: Remote management and monitoring of farm activities gives farmers flexibility and convenience.
8. **Market Access**: Farmers' access to markets and supply chains can be facilitated by technology, potentially improving their revenue and market reach.

Disadvantages of smart agriculture

1. **High Initial Costs**: Some small-scale or resource-constrained farmers may not be able to implement smart agricultural technology due to their high cost.
2. **Complexity**: Not all farmers have the specialised expertise and abilities needed to implement and manage these technologies.
3. **Data Privacy and Security**: Concerns regarding privacy and the possibility of data breaches might arise from the collection and storage of sensitive agricultural data.
4. **Dependence on Technology**: If there are technological problems or interruptions, relying too heavily on technology might put farmers at danger.
5. **Uneven Access**: Agriculture inequities may be made worse by differences in access to technology and internet connectivity, which favours larger and wealthier farmers.
6. **Environmental Concerns**: If improperly handled, some precision agricultural techniques may have unforeseen negative effects on the environment, such as excessive fertiliser runoff.
7. **Energy Consumption**: Technology-driven agriculture systems may need a lot of energy to implement and operate, which might increase greenhouse gas emissions.

8. **Resistance to Change**: Due to their attachment to tradition, scepticism, or worries about losing control of their businesses, some farmers may be reluctant to accept new technology.

Status of smart agriculture in India today

As of right now, India's smart agriculture has developed and broadened its application. To improve agricultural practises, the public sector, the corporate sector, and agricultural communities have all embraced digital technology more and more. The use of smartphones and mobile apps to obtain real-time meteorological data, market pricing, and crop management guidance has increased substantially, giving farmers access to important data. Farmers can now more accurately monitor soil conditions, crop health, and irrigation demands thanks to the proliferation of IoT devices and sensors. Drones and UAVs are being used more often for activities including crop observation, pest management, and accurate mapping of agricultural land. The advancement of machine learning and artificial intelligence applications has also aided in data analysis for pest control, disease identification, and agricultural production optimisation. agricultural management software is still essential for optimising agricultural operations and raising output in general. While there are still issues like the digital divide and access to technology in rural regions, smart agriculture in India is progressing towards more efficient and sustainable farming methods.

Procedure for adapting smart agriculture in India

Adopting smart agriculture practices in India involves several key steps:

1. **Assess Local Needs**: Assessing the unique requirements and difficulties faced by neighbourhood farmers is the first step. This entails taking into account elements including climate, soil type, crop variety, and current methods for agriculture. Knowing these elements enables the development of smart agricultural solutions that are specific to the needs of the area.
2. **Access to Technology**: Make sure farmers can obtain the tools they need. This involves bringing inexpensive cellphones and internet connection to rural communities, as these gadgets are essential for gaining access to management tools, market data, and agricultural statistics.
3. **IoT Implementation**: Install Internet of Things (IoT) gadgets and sensors in agricultural areas to gather information on crop health, soil temperature, and moisture content. Making educated judgements about irrigation, fertilisation, and pest management is possible with the use of this data.
4. **Farm Management Software**: Introduce mobile apps and farm management software that includes functions like crop planning, managing pests and diseases, and inventory monitoring. These products help farmers in streamlining their processes and raising production.
5. **Training and Education**: To inform farmers about smart agricultural technology and their effective usage, conduct training programmes and workshops. Extension services may be extremely important in spreading information and best practises.
6. **Government Support**: Encourage government financing and programmes that assist smart agricultural efforts, such as grants for technology adoption, funds for research and development, and rewards for environmentally friendly farming methods.
7. **Collaboration**: To develop and execute smart agriculture solutions, encourage collaboration between governmental organisations, agricultural institutions, and the corporate sector. Collaborations might hasten the implementation of these technologies.
8. **Monitoring and Evaluation**: Continually gather information on crop yields, resource efficiency, and economic results to assess the effects of smart agricultural practises. This information can guide changes and enhancements to the technology used.
9. **Scaling Up:** Expand smart agriculture programmes gradually to encompass wider agricultural areas while taking into consideration the knowledge gained from pilot programmes. The production of food and rural lives may be

significantly impacted by scaling up these practises.

10. **Sustainability and Resilience**: Promote environmentally friendly and climate-resilient farming methods as a crucial component of smart agriculture. To achieve long-term advantages, this involves supporting organic farming, conservation agriculture, and effective resource use.

Conclusions

In conclusion, smart agriculture is a revolutionary method of farming that uses modern technology and data-driven solutions to tackle today's most serious problems. Smart agriculture increases production, reduces resource waste, and fosters sustainability by merging IoT devices, AI algorithms, and precision agriculture methods. It provides farmers with real-time insights that enable them to optimise their operations and make wise decisions. Additionally, it promotes the shift to more effective and environmentally friendly farming methods, lessens the impact on the environment, and increases food security. Future generations will be able to feed a growing global population while also protecting our planet's valuable resources thanks to the continuous development and acceptance of smart agricultural technology.

Table 1: Few Sensors and their applications

S.No.	Sensors	Sensors Applications	Working Procedure
1.	Acoustic sensors	Pest monitoring and detection classifying seed varieties, fruit harvesting.	Measuring the variations in noise level when intermingling with other materials, i.e., soil particles.
2.	Airflow sensors	Measuring soil air permeability, moisture, and structure in a static position or mobile mode.	Based on various soil properties, unique identifying signatures.
3.	Electromagnetic sensors	Recording electrical conductivity, electromagnetic responses, residual nitrates, and organic matter in soil.	Electrical circuits measure the capability of soil particles to conduct or accumulate electrical charge.
4.	Remote sensing	Crop assessment, yield modeling, forecasting yield date, land cover and degradation mapping, forecasting, the identification of plants and pests, etc.	Satellite-based sensor systems collect, process, and disseminate environmental data from fixed and mobile platforms
5.	Ultrasonic ranging sensors	Tank monitoring, spray distance measurement, uniform spray coverage, object detection, monitoring crop canopy, and weed detection.	An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay information about an object's proximity.

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Nutritional Profile of Poultry Offal and Its Utilisation as Fish Feed

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Poultry offal meal (POM) is an animal by-product, generally consisting of parts of the animal considered ill-favoured for human consumption. High in protein, with an essential amino acid profile that more closely resembles fishmeal in comparison to terrestrial plant derived protein sources (Riche, 2015). POM is low in ash and contains little to no anti-nutritional factors found in plant-derived protein sources (e.g., proteolytic enzyme inhibitors) (Francis et al., 2001). Due to its afore mentioned advantages, global use of POM-based aqua feed has steadily increased (Badillo et al., 2014; Riche, 2015). The suitability of POM inclusion has been evaluated for many commercially important aquaculture species, including Oncorhynchus mykiss (rainbow trout) (Badillo et al., 2014), Lates calcarifer (barramundi) (Lewis et al., 2019), and Salmo salar (Atlantic salmon) (Hatlen et al., 2015). Despite its widespread utilisation in aquafeed, the confidence of aquafeed manu-facturers to utilise POM as a protein source is currently hindered by high variation in both nutritional value and digestibility. Nutritional quality of a meal (i.e., the protein source within the diet) is directly linked to the essential amino acids present and their bioavailability, the structure of the proteins present, and the ability of digestive enzymes to act upon these proteins, which in-turn determines its digestibility (Friedman, 1999; Gilani et al., 2005). A decrease in di-gestibility and concomitant degradation of the nutritional value of protein meals can be attributed to the destruction of amino acids, a reduction in amino acid bioavailability, changes to protein structures and an inhibition of digestive enzyme activities. Therefore, in order to avoid negative downstream effects on digestibility, feed utilisation, and performance, the raw material source and processing methods must be scrutinised to ensure the resulting meals are highly digestible and balanced with essential amino acids.

Chemical properties

Poultry offal (PO) is a diverse material (Mayer, 1990). Most of the protein is derived from connective tissues. The average crude protein of PO is 61% ranges from 56.4 to 84.2%. PO is a good source of essential amino acids (Evans, M. 1985).

Table 1: Chemical composition (%) of poultry offal. (Dupree and Huner, 1984), (Meyer and Heckotter, 1986)

Proximate composition	Ranges
Dry matter	89.9-95.0
Crude protein	56.4-84.2
Crude fat	10.0-29.4
Ash	3-18
Crude fibre	0.4-3.6
N- free extract	2.0-5.4

Table 2: Essential amino acid profile of poultry offal (g/12gN)

Amino acids	Ranges
Arginine	2.64-6.60
Histidine	0.75-1.43
Isoleucine	1.92-10.70
Leucine	3.34-9.50
Lysine	2.40-3.77
Methionine	0.77-2.80
Phenylalanine	1.67-5.30
Threonine	1.68-2.90
Tryptophan	0.46-0.80
Valine	2.18-3.50

The fat content of poultry offal depends not only on the technique of processing but also on the raw materials, especially if the abdominal fat is present in large amount (Evans, 1985). The fat content therefore ranges widely but it is high in unsaturated fatty acids as follows (Mayer et al, 1986).

Total saturated fatty acids: 32.6%

Total unsaturated fatty acids: 63.1%

PUFA (Polyunsaturated fatty acids): 17.6%

Linoleic acids: 16.5%

Linolenic acids: 1.1%

The crude fibre content of poultry offal is solely from the chyme crude fibre and the keratin of the feet. The differences of the ash content are high and may jump up since consumes gradually more prefer processed poultry meat than whole carcasses so that more bones go to the offal. (NRA, 1993): Poultry offal is a reliable source of iron and zinc along with choline.

Table 3: Vitamins and minerals content of poultry offal (Evans, 1985; Meyer & Heckotter, 1986; New 1987)

Vitamins (mg)	Minerals
Vitamin E (mg)- 2.05	Calcium (%)- 3.36
Vitamin B1(mg)- 0.20	Phosphorus (%)- 1.77
Vitamin B2 (mg)- 10.50	Sodium (%)- 0.50
Vitamin B6 (mg)- 4.40	Potassium (%)- 0.42
Vitamin B12 (mcg)- 306	Magnesium (%)- 0.13
Folic acid (mg)- 0.75	Chlorine (%)- 0.54
Nicotinic acids (mg)- 43.4	Sulphur (%)- 0.52
Panthotenic acids (mg)- 9.95	Manganese (mg/Kg)- 11.0
Choline (g)- 4.10	Iron (mg/Kg)- 506.0
	Zinc (mg/Kg)-99.8
	Copper(mg/Kg)- 9.7
	Selenium (mg/Kg)- 0.78

Utilisation of poultry offal as fish feed.

In intensive and semi-intensive aquaculture system, 60-70% of the operational cost comes from feed. Therefore, there is a necessity to reduce feed cost by using locally available and low-cost feed ingredients. The most expensive ingredient for the formulation of fish feed is animal protein source. Fish meal (FM) is the sole regular animal protein source for fish and there is competition with farmer like poultry and other livestock. As a consequence, the price of FM is increased and its incorporation in feed scarcely allows profitable fish farming. Therefore, there is a need to find alternative source of animal protein for manufacturing fish feed. Poultry offal is one of the most promising alternate protein sources. Bulbul and Islam (1991) suggested broiler offal as a high-quality animal protein. It consists of heads, feet, underdeveloped eggs and viscera. Broiler Offal contained reasonable number of proximate components, essential amino acids and important minerals. The inclusion of poultry by-products (PB) in fish diets was found to depend on fish species and size as well as composition and processing techniques of PB. Lu and At a 100% substitution level, fish growth was significantly reduced. However, a mixture of PB and feather meal supplemented with essential amino acids completely replaced FM in rainbow trout diets.

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Improving Nitrogen Use Efficiency in Lowland Rice: Practical Strategies for Addressing Reactive Nitrogen Loss

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The large-scale popularization and adoption of some of the emerging and promising N management practices is a great challenge. The major underlying reasons for this include lack of technical know-hows for using a leaf colour chart and chlorophyll meter, high-cost involvement with urease inhibitor and controlled release fertilizers, extra labour requirements for urea deep placement, and unavailability of biochar and nitrification inhibitors at farmers' level. This calls for the development of farmer-friendly fertilizer management approaches. Necessary steps should be taken by policymakers to ensure availability and adoption of such technologies at the farmers' level through greater extension efforts. This review identifies a set of available N management practices and some best tools for improving NUE in wetland rice in a sustainable and ecofriendly manner and at the same time not compromising with the yield. Deliberate application of recommended N management tools in rice cultivation might reduce the loss of N and thereby increase NUE, which will ultimately contribute towards climate change mitigation ensuring environmental sustainability.

Strategies to enhances NUE in lowland rice

Nitrogen management is the key for sustainable and profitable rice production in India. Nitrogen recovery can be improved through adoption of locally as well as scientifically available means of N management to ensure efficient use of agricultural inputs (chemical fertilizers, organic inputs, environmental input, and crops) that will enhance beneficial use of N in crops and minimize its losses (**Figure 1**). Various strategies (**Figure 2**) based on above discussed approach for improving NUE will be discussed below:

Soil test-based fertilization

Soil test- based fertilization is a vital component of the 4R strategy for nutrient management i.e., Right place, Right time, Right source, and Right rate. The 4R technique (**Figure 3**) minimizes nutrient losses, improve NUE, and reduces adverse effects on environmental.

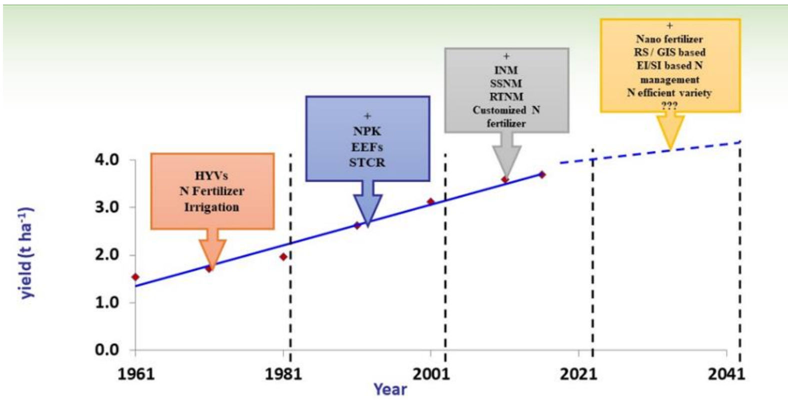

Figure 1: Scaling up of innovation of agronomic N management technologies for enhancing rice yield

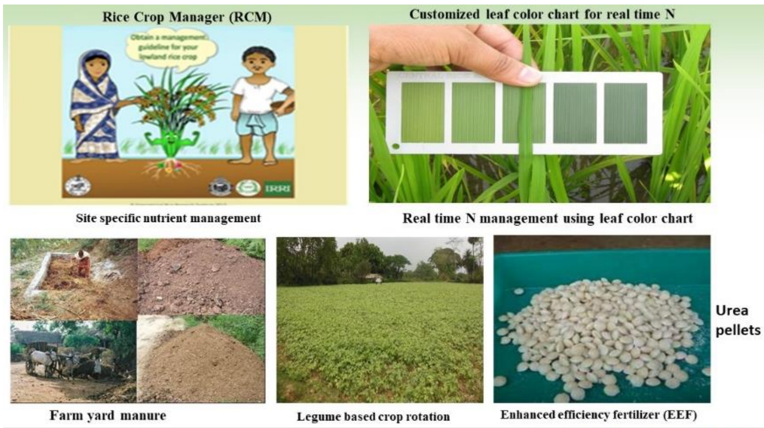

Figure 2: Different nitrogen-smart technologies for lowland rice

Nutrient expert-based N management

A developing N management evaluation tool called Nutrient Expert applies fertilizers at the proper time, place, and amounts (a variable rate application) depending on the needs of the crop plants. It makes it easier to use inputs more effectively, saves money on fertilizer, and ensures that natural resources are used sustainably.

Site Specific Nutrient Management (SSNM)

The SSNM is a concept that encompasses field-specific N management strategies that include quantitative knowledge of field-specific variability in crop N demand and expected soil N supply capacity. The SSNM approach was introduced to improve NUE in wetland rice. In this approach, several factors are considered in calculating the appropriate N requirement for the crop. Factors include a crop's nutrient requirements, target yield, temperature, solar radiation, soil N supply, irrigation, mineralization of crop residues, and other organic matter.

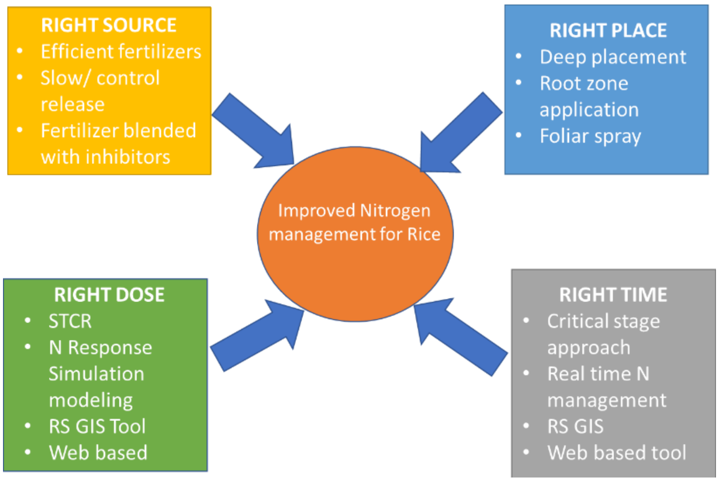

Figure 3: 4R stewardship for enhancing nitrogen use efficiency

Leaf Colour Chart (LCC)

Leaf colour chart is a diagnostic tool that helps farmers make decisions regarding the scheduling of N fertilizer applications in standing crops. Conventionally, growers rely on visual observations to assess crop nutrient status, particularly N levels. Leaf colour chart can serve as a diagnostic tool for plant health, especially for optimizing N supply to rice crops. Nitrogen is one of the main components of leaf chlorophyll. Its measurement at different phenological stages therefore serves as an indirect basis for N management. In China, a group of farmers were able to save 25% N fertilizer without affecting yield through LCC-guided N management in hybrid rice.

Chlorophyll meter (Soil Plant Analysis Development (SPAD))

The N status of crops can be assessed using a chlorophyll meter because most N is found in the chloroplasts of plants. Therefore, it is closely related to leaf chlorophyll content. SPAD meters, better known as chlorophyll meters, provide relative measurements of leaf chlorophyll content. Chlorophyll meters can self-calibrate with changing soils, seasons, and varieties. It is also recommended to evaluate the effectiveness of late-applied N in standing crops to increase grain yield and protein content. SPAD meter-based SSNM approach has been extensively demonstrated in Southwest Asian countries such as China, India, and Bangladesh.

Slow and controlled released fertilizer

Slow-release fertilizers (**Table 1**) appropriate modification in fertilizer source or management practices can lead to reduced losses of N and increased fertilizer NUE. Slow-release N fertilizer developed by coating urea granules with sulphur has been tested vis-a-vis ordinary urea in rice and this material out performed ordinary urea in almost all types of soils. A range of slow-release fertilizers is now marketed which have the potential to reduce various N losses and improve NUE. Controlled release N fertilizers offer a good option to reduce N losses from the system because their Slow and delayed N release strategy that balances crop demand and N requirements.

Table 1: Various slow and controlled release N fertilizers

Fertilizer Forms	Example
Coated with inert material	Urea coated with polymer, lac, gypsum, sulphur and rock phosphate
Enlargement of the granule	Urea super granule, granular urea
Limited solubility forms of urea	Urea form, oxamide, Urea -z
Coated with urease inhibitors	Hydroquinone, phenyl phosphor deamidate (PPD)
Coated with nitrification inhibitors	Nitra pyrin, DMPP, DCD, ATC (4-amino - 1,2,4-triazole)

Nitrification inhibitors

Nitrification inhibitors, which slow the conversion of NH_4^+-N into NO_3^-- N, have been reported to increase NUE and crop yield. Application of nitrification inhibitors could also have considerable influence on emissions of N_2O and CH_4 from soil. Further research and development are needed to identify cheap locally available materials such as neem cake and neem oil, which can inhibit nitrification and increase NUE. Several nitrification inhibitors that are widely used in agriculture include: 2-chloro-6-(trichloromethyl) pyridine (nitrapyrin), dicyandiamide (DCD), and 3,4-dimethylepyrazole phosphate (DMPP).

Right method of N Application

Foliar Application

Foliar application helps to improve the NUE in farmers field by reducing surface runoff, microbial immobilization, leaching, volatilization and denitrification. Nano-urea, hydro nano-urea, nano-DAP these are applied through foliar methods to improve the NUE and help in quick recovery from N deficiency in rice land.

Deep placement

One of the most effective N management strategies created for rice is the deep-point placement of urea supper granule (USG) at a depth of 5-10 cm. However, it is labour-intensive. It is demonstrated that deep placement of urea reduced N loss by 65% and increased grain production of rice by 50% when compared to split application of granular urea.

Resource conservation technology (RCT)

Any technology that increases the effectiveness of the application or use of resources is called RCT. It helps to increase rice production and protect topsoil. Technology is being developed to regulate N in low-lying areas while conserving resources are conservation agriculture, crop residue retention, green manure, zero tillage, laser land levelling, direct seeding of rice and leaf colour chart.

Integrated nutrient management (INM)

Integrated N management requires the most use of locally available N components, such as crop wastes, organic manure, biological N fixation, and chemical fertiliser, as well as their complementing interactions to improve N recovery. The synergistic effects of integrated use of organic and inorganic N sources are due to either an optimal physicochemical soil environment or improved root growth and supply of secondary and micronutrients. Proper understanding and utilisation of these positive plant nutrient interactions is important to increase farmers' returns in terms of yields, improve soil quality, and increase NUE. The complementary interactions of N with other macro- and micronutrients could lead to significant improvements in yield and NUE. Therefore, balanced and prudent use of nitrogen by all available means will result in higher productivity.

Android App

RiceNxpert

This app captures photos of 10 fully developed healthy rice leaves with a white background. Nitrogen fertilisation recommendations for different rice ecologies when the green colour is less than the Pantone critical standard leaf colour.

RiceXpert

The app provides farmers with real-time information on rice varieties for different ecologies, pests, nutrients, weeds, nematodes, and disease-related problems, as well as farm equipment for different field and post-harvest practices. Farmers can use this app as a diagnostic tool in their rice fields and make customized requests to quickly solve their problems by sending a text, photo or voice recording. The app was developed for the Android platform and can be downloaded from the Google Play Store or from www.nrri.in.

Conclusion & future prospects

Addressing reactive N loss in lowland rice cultivation is essential to improve NUE, minimize environmental impacts, and ensure sustainable production. Nitrogenous fertilizers are quickly lost from the soil system through various mechanisms, for enhanced crop N uptake, N supply should be in synchrony with the N demand. Future prospects for addressing reactive N loss in lowland rice involve continued research and innovation. This includes developing improved varieties with enhanced NUE, exploring novel fertilizer formulations or delivery systems, and advancing precision agriculture technologies for more precise N management. Additionally, promoting awareness and providing training to farmers on best management practices for N utilization and environmental stewardship will be crucial for widespread adoption. By implementing the strategies and embracing future advancements, it is possible to mitigate N losses in lowland rice cultivation, enhance crop productivity, and contribute to sustainable agriculture and environmental conservation.

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Biofertilizers: Enhancing Crop Production and Nurturing Soil Fertility

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In the quest for sustainable and eco-friendly agricultural practices, biofertilizers have emerged as a key player in promoting crop production and maintaining soil fertility. Unlike traditional chemical fertilizers that can have adverse effects on the environment and human health, biofertilizers leverage the power of beneficial microorganisms to enhance nutrient availability and support plant growth. This article explores the pivotal role that biofertilizers play in modern agriculture, emphasizing their impact on both crop yield and soil health.

Biofertilizers

Biofertilizers, comprised of living microorganisms essential for soil fertility and plant growth, facilitate natural processes like nitrogen fixation, phosphorus solubilization, and the production of growth-promoting chemicals. Through these mechanisms, biofertilizers contribute to the restoration of the soil's natural nutrient cycle and the enhancement of soil organic matter. Application of biofertilizers fosters the development of robust and healthy plants, concurrently promoting soil sustainability. While reducing the dependence on synthetic fertilizers and pesticides, biofertilizers may not entirely substitute for these conventional inputs.

Biofertilizers can be categorized based on the type of microorganism they contain. The main types include:

1. Bacterial Biofertilizers: Examples include Rhizobium, Azospirillum, Azotobacter, and Phosphobacteria.

2. Fungal Biofertilizers: Mycorrhiza is a notable example of fungal biofertilizers.

3. Algal Biofertilizers: Blue-Green Algae (BGA) and Azolla fall under the category of algal biofertilizers.

4. Actinomycetes Biofertilizer: Frankia is an example of a biofertilizer containing actinomycetes.

Types of Biofertilizers

Nitrogen-Fixing Biofertilizers

Nitrogen is an essential nutrient for plant growth, and certain bacteria, such as Rhizobium and Azotobacter, have the ability to convert atmospheric nitrogen into a form that plants can use. Leguminous crops, like peas and beans, form mutualistic relationships with Rhizobium bacteria, allowing them to fix nitrogen and provide it to the plant.

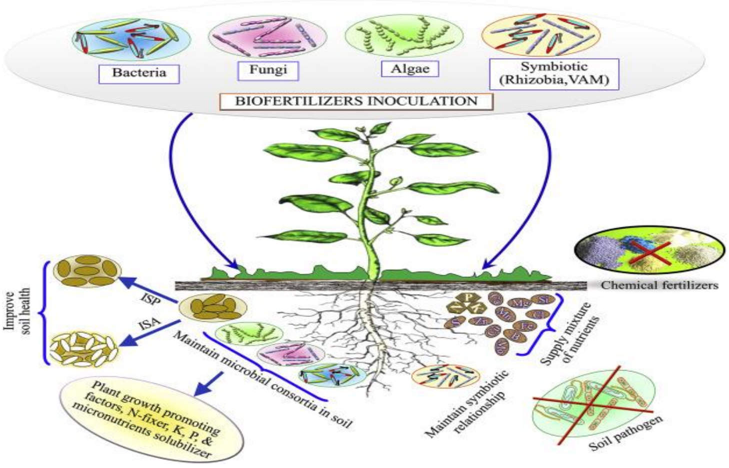

Fig:1 Types of Biofertilizer

Phosphate-Solubilizing Biofertilizers

Phosphorus is crucial for plant development, and phosphate-solubilizing bacteria, such as Pseudomonas and Bacillus, play a vital role in making phosphorus more accessible to plants. These bacteria release organic acids that dissolve insoluble phosphates in the soil, making them available for plant uptake.

Potassium-Releasing Biofertilizers

Certain bacteria, like Bacillus mucilaginosus, help release potassium from mineral complexes in the soil, making it more readily available to plants. Potassium is essential for various physiological processes in plants, including water uptake, photosynthesis, and enzyme activation.

Benefits of Biofertilizers

Improved Soil Structure

The use of biofertilizers enhances soil structure by promoting the growth of beneficial microorganisms. This, in turn, increases soil porosity and water retention, facilitating better aeration and nutrient availability for plants.

Reduced Environmental Impact

Unlike chemical fertilizers, biofertilizers are environmentally friendly. They do not contribute to soil and water pollution, and their use reduces the overall carbon footprint associated with agriculture.

Enhanced Nutrient Uptake

Biofertilizers improve nutrient uptake by plants through symbiotic relationships and by solubilizing nutrients in the soil. This results in increased crop yield and improved nutritional quality.

Disease Suppression

Some biofertilizers exhibit antagonistic properties against plant pathogens, helping to suppress diseases and protect crops naturally. This reduces the reliance on chemical pesticides and fosters a more sustainable agricultural ecosystem.

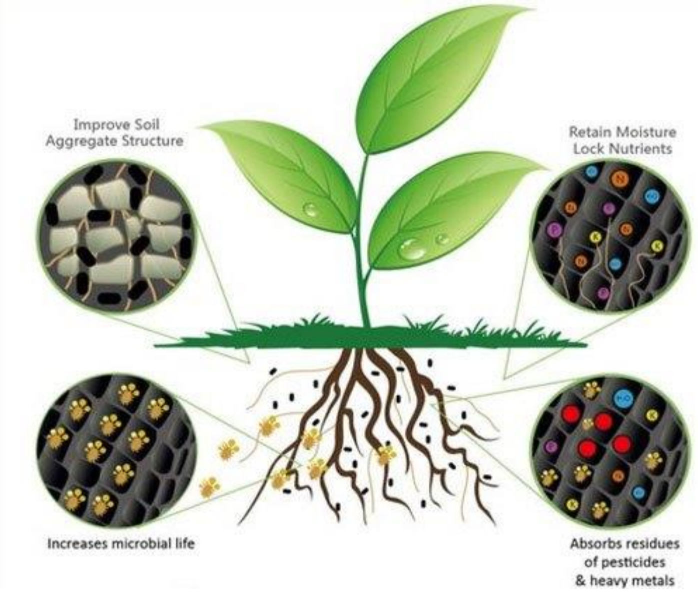

Fig:2 Benefits of Biofertilizer

Application of biofertilizers to crops

Seed treatment

For seed treatment, blend each 200g packet of inoculant with a 200 ml solution of rice gruel or jaggery. Mix the seeds needed for one hectare in the resulting slurry to ensure a consistent coating of the inoculant, then allow them to air-dry in the shade for 30 minutes. It is crucial to utilize the treated seeds within 24 hours. One packet of inoculant is ample for treating 10 kg of seeds. Seed treatment involves the application of Rhizobium, Azospirillum, Azotobacter, and Phosphobacteria.

Set/Cutting treatments

For cuttings (vegetative propagation), treatments might include the application of rooting hormones or dipping in nutrient-rich solutions to stimulate root development before planting.

Seedling root dip

This method is used for transplanted crops. To treat one hectare, five packets (1.0 kg each) of inoculants are combined with 40 liters of water. The root section of the seedlings is immersed in the solution for 5 to 10 minutes before transplanting. Notably, Azospirillum is specifically utilized for the root dip of rice seedlings in this process.

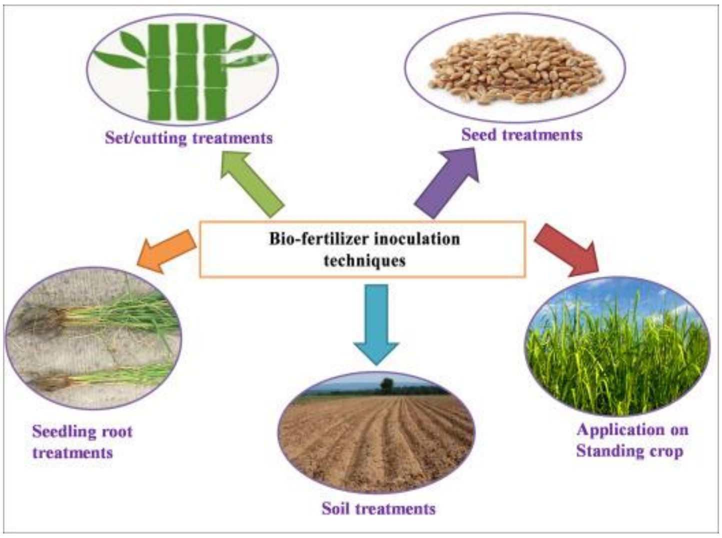

Fig:3 Application of Biofertilizer

Soil treatment

A blend of 4 kg each of the recommended biofertilizers is combined with 200 kg of compost, allowing the mixture to stand overnight. This composite is then integrated into the soil during the sowing or planting phase.

Application on standing crop

The application on a standing crop involves administering the recommended biofertilizers directly to the established and growing plants. This is typically done during the vegetative or reproductive stages of the crop. The biofertilizers are often applied to the soil surrounding the crop or sprayed onto the foliage, allowing the living microorganisms to interact with the plant's root system or be absorbed through the leaves. This method supports the ongoing growth and development of the standing crop, promoting enhanced nutrient uptake and overall plant health.

Use of VAM Biofertilizer

- Apply the inoculum 2-3 cm below the soil surface during sowing.
- Sow seeds or plant cuttings just above the VAM inoculum layer to ensure root contact and infection.
- For a one-meter square area, 100g of bulk inoculum is adequate.
- Polythene bag-raised seedlings require 5-10g of bulk inoculum per bag.
- During sapling planting, apply VAM inoculum at a rate of 20g per seedling at each spot.
- Existing trees need 200g of inoculum per tree during application.

Use of Blue Green Algae (BGA)

* Apply algal culture in the form of dried flakes at a rate of 10 kg/ha over the standing water in rice fields.
* Perform this application two days after transplanting in loamy soils and six days after planting in clayey soils.
* Maintain waterlogging in the field for a few days immediately following algal application.
* Continue the application of the biofertilizer for 3-4 consecutive seasons in the same field.

Use of Azolla

* **Green manure:** Apply Azolla at a rate of 0.6-1.0 kg/m2 (equivalent to 6.25-10.0 t/ha) and incorporate it before transplanting rice.
* **Dual crop:** Apply Azolla at 100 g/m2 (1.25 t/ha) one to three days after transplanting rice, allowing it to proliferate for 25-30 days. Incorporate Azolla fronds into the soil during the first weeding.

Precautions to take while using biofertilizers

- Store biofertilizer packets in a cool, dry place away from direct sunlight and heat.
- Utilize the right combinations of biofertilizers.
- Since Rhizobium is crop-specific, apply it only to the specified crop.
- Avoid mixing other chemicals with biofertilizers.
- When purchasing, ensure each packet includes essential information such as product name, intended crop, manufacturer's name and address, date of manufacture, expiry date, batch number, and usage instructions.
- Use the packet before its expiry, exclusively for the specified crop and through the recommended application method.
- Recognize that biofertilizers are living products and necessitate careful storage.
- Achieve optimal results by using both nitrogenous and phosphatic biofertilizers.
- Complement plant nutrient needs by using biofertilizers alongside chemical fertilizers and organic manures. Biofertilizers are not a substitute for fertilizers but rather serve as a supplement to meet plant nutrient requirements.

Constraints in biofertilizer use

Despite little investment, eco-friendly character, and advantages of biofertilizers, adoption of this organic input by farmers has remained far from satisfactory. There are several constraints at production, marketing, and field level which limit the adoption of biofertilizers among the wide community of farmers.

While biofertilizers offer numerous benefits, their use is not without constraints. Several challenges and limitations may affect their widespread adoption in agriculture. Some key constraints of biofertilizer use include:

Specific Crop Suitability

Biofertilizers may exhibit varying effectiveness with different crops. Some strains of beneficial microorganisms may be more suitable for certain plants, limiting the universal applicability of biofertilizers across diverse crop varieties.

Environmental Sensitivity

The performance of biofertilizers is often influenced by environmental conditions such as temperature, pH levels, and soil moisture. Extreme conditions may affect the viability and activity of the microorganisms, impacting their efficacy.

Storage and Shelf Life

Biofertilizers are living organisms that require careful handling and storage. Maintaining their viability during storage can be challenging, and the shelf life of some biofertilizers may be limited. This poses logistical challenges for distribution and long-term storage.

Variable Performance

The effectiveness of biofertilizers can vary depending on soil types and microbial interactions. In some cases, the desired impact on nutrient availability and crop growth may not be consistent, leading to unpredictable results.

Integration with Chemical Fertilizers

Achieving an optimal balance between biofertilizers and chemical fertilizers can be complex. In certain situations, the compatibility and interactions between these inputs may not be fully understood, potentially limiting their combined benefits.

Cost Considerations

Biofertilizers, particularly those containing specialized strains of microorganisms, can be more expensive than conventional chemical fertilizers. This cost factor may discourage widespread adoption, especially in regions with limited financial resources.

Educational Awareness

Farmers may lack awareness and understanding of the benefits and application methods of biofertilizers. Promoting education and awareness about the use and advantages of biofertilizers is crucial for their successful integration into farming practices.

Production Challenges

Large-scale production of high-quality biofertilizers can be challenging. Maintaining consistency in microbial content, ensuring purity, and meeting regulatory standards add complexity to the production process.

Time Constraints

Biofertilizers may take longer to show noticeable effects compared to some chemical fertilizers. In situations where rapid nutrient availability is critical, the time lag associated with biofertilizers could be a limiting factor.

Policy and Regulation

Regulatory frameworks for biofertilizers may not be well-established in some regions. Lack of clear guidelines and standards can hinder their adoption and market penetration.

Despite these constraints, ongoing research and technological advancements aim to address these challenges, making biofertilizers more efficient, cost-effective, and user-friendly for sustainable agricultural practices.

Future Perspectives

The future of biofertilizers looks promising, with ongoing research, technological advancements, and a growing emphasis on sustainable agriculture driving their development and adoption. As the demand for environmentally friendly and sustainable farming practices increases, biofertilizers are likely to play a crucial role in shaping the future of agriculture.

Conclusion

In the face of increasing environmental concerns and the need for sustainable agricultural practices, biofertilizers stand out as a promising solution. Their ability to enhance crop production, improve soil fertility, and mitigate environmental impact positions them as a key player in the quest for a more sustainable and resilient global agriculture system. As technology advances and our understanding of microbial interactions deepens, the role of biofertilizers is likely to expand, contributing significantly to the future of agriculture.

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Achieving High Yielding Plant Type Through Ideotype Breeding

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To accomplish the mark yield that is essential to endure the world population, crop varieties with a yield advantage of about 25% over currently grown varieties must be developed. Yield potential is defined as the yield of a variety when grown in environments to which it is adapted, with nutrients and water non-limiting and with pests, diseases, weeds, lodging, and other stresses effectively controlled (Carkner *et al*., 2023). Plant breeding is mostly based on "defect elimination" or "selection for yield". A valuable additional approach is breeding for crop ideotypes; plants with model characteristics known to influence photosynthesis, growth and (in cereals) grain production. An optimized crop ideotype will make a minimum demand on resources per unit of dry matter produced. Further, in cereals, each unit of dry matter will include such a number of florets as to ensure that the ear has sufficient capacity to accept all photosynthates either from its own green surfaces or from other parts of the plant. The concept of plant type was introduced in rice breeding (Jennings, 1964) while the term ideotype was coined by Donald in 1968. These criteria are to be satisfied especially at high fertility, and when the total pressure by the community on environmental resources is intensified by high population density (Donald, 1968). The crop ideotype consists of those morphological and physiological traits that will contribute to higher yield than currently prevalent crop cultivars.

Features of ideotype breeding

Ideotype breeding or plant type breeding can be defined as a method of crop improvement which is used to enhance yield potential through genetic manipulation of individual plant characters are chosen in such a way that each character contributes towards increased economic yield. Main features of Ideotype breeding are briefly discussed below: Emphasis on Individual Trait:

Emphasis on individual traits

In Ideotype breeding emphasis is given on individual morphological and physiological trait which enhances the yield. The value of each character is specified before initiating the breeding work.

Includes Yield Enhancing Traits

Various plant characters to be included in the Ideotype are identified through correlation analysis. Only those characters which exhibit positive association with yield are included in the model.

Exploits Physiological Variation

Genetic difference exists for various physiological characters such as photosynthetic efficiency. Photo respiration, nutrient uptake, etc. Ideotype breeding makes use of genetically controlled physiological variation in increasing crop yields, besides various agronomic traits.

Slow Progress

Ideotype breeding is a slow method of cultivar development, because incorporation of various desirable characters from different sources into a single genotype takes long time. Moreover, sometimes undesirable linkage affects the progress adversely.

I. **Selection:** In Ideotype breeding selection is focussed on individual plant character which enhances the yields.
II. **Designing of Model:** In Ideotype breeding, the phenotypes of new variety to be developed is specified in terms of morphological and physiological traits in advance.
III. **Interdisciplinary Approach:** Ideotype breeding is in true sense an interdisciplinary approach. It involves scientist from the disciplines of genetics, breeding, physiology, pathology, entomology etc.
IV. **A Continuous Process:** Ideotype breeding is a continuous process, because new Ideotype have to be developed to meet changing and increasing demands. Thus, development of Ideotype is a moving target.

Features of Crop Ideotype

The crop Ideotype consists of several morphological and physiological traits which contribute for enhanced yield or higher yield than currently prevalent crop cultivars. The morphological and physiological features of crop Ideotype is required for irrigated cultivation or rainfed cultivation. Ideal plant whether the Ideotype is required for irrigated cultivation or rainfed cultivation. Ideal plant types or model plants have been discussed in several crops like wheat, rice, maize, barley, cotton, and bean. The important features of Ideotype for some crops are briefly described below:

Wheat

The term Ideotype was coined by Donald in 1968 working on wheat. He proposed Ideotype of wheat with following main features. A short strong stem. It imparts lodging resistance and reduces the losses due to lodging. Erect leaves. Such leaves provide better arrangement for proper light distribution resulting in high photosynthesis or CO_2 fixation. Few small leaves. Leaves are the important sites of photosynthesis, respiration, and transpiration. Few and small reduce water loss due to transpiration. Larger ear. It will produce more grains per ear. A presence of owns. Awns contribute towards photosynthesis. Presence of awns. Awns contribute towards photosynthesis. A single culm.

Considered tillering as important features of wheat flag type a wheat plant with moderately short but broad flag leaf, long flag leaf sheath, short ear extrusion with long ear, and moderately high tillering capacity should give yield per plant.

Rice

The concept of plant type was introduced in rice breeding by Jennings in 1964, through the term Ideotype was coined by Donald in 1968. He suggested that the rice an ideal or model plant type consists of semi dwarf stature. High tillering capacity, and Short, erect, thick and highly angled leaves. High biomass, high kernel weight with high numbers.

It was observed that reduced tillering contributed to lower biomass. Some of these lines shows good performance in temperate areas, where japonica grain quality is preferred (Sharma *et al.*,2013). Three of these lines were released as a variety in Yunnan province of China as Diancho 1, Diancho 2 and Diancho 3. Also develop the 'Super' Rice variety with a maximum yield 9 to 10.5t-ha^{-1}.

Maize

In 1975, Mock and Pearce proposed ideal plant type of maize. In Maize, higher yields were obtained from the plants consisting of Low tillers, large cobs, and angled leaves for good light interception. Planting of such type at closer spacings resulted in higher yields.

Barley

Rasmusson (1987) reviewed the work on Ideotype breeding and also suggested ideal plant type of six rowed barley. He proposed that in barley, higher yield can be obtained from a combination of Short stature, Long awns, High harvest index, and High biomass. Kernel weight and kernel number were found rewarding in increasing yield.

Cotton

In cotton, genotypes with zero branch, short stature, compact plant, small leaves and fewer sympodia were considered to enhance yield levels. Singh et al. (1974) proposed and ideal plant type of plant cotton growing belt. The proposed Ideotype includes short stature (90-120 cm), compact and sympodial plant habit making pyramidal shape, determinate the fruiting habit with unimodal distribution of bolling, short duration (150-165 days), responsive to high fertilizer dose, high degree of inter plant competitive ability, high degree of resistance to insect pests and diseases, and high physiological efficiency, Singh and Narayana (1993) proposed an Ideotype of above two species for rainfed conditions. The main features of proposed Ideotype include, earliness (150-165 days), fewer small and thick leaves, compact and short stature, interminate habit, spares hairiness, medium to big boll size, synchronous bolling, high response to nutrients, and resistance to insect and diseases.

Sorghum and Pearl millet

Improvement in plant type has been achieved in Sorghum and Pearl millet through the use of dwarfing genes. In these crop dwarf F1 hybrids have been developed which have made combine harvesting possible. Genetic improvements have been achieved thorough modification of plant type in several crop species. New Ideotype have been proposed for majority of crop plants. Several desirable attributes of crop Ideotype with special reference to multiple cropping in the tropics and sub tropics. These features include: Superior population performance, high productivity per day, high photosynthetic ability, Low photo respiration, Photo and thermo sensitivity, high response to nutrients, high productivity per unit of water, Multiple resistances to insect and diseases, better protein quantity and quality. Crop canopies that can retain and fix a maximum of CO_2, and suitability to mechanization.

Future Prospects of Ideotype Breeding in India

In India, the future research on crop Ideotype should be directed towards following aspects:

1. India has attained self-adequate in the production of food grains through alteration of plant characters and development of high yielding varieties/ hybrids (Singh, 2013). The further breakthrough in yield and quality has to be achieved through the exploitation of physiological variation. Ideotype both for high and low input technology condition have to be developed.
2. To further the yield potential of food grain crops, Ideotype have to be evolved for straight varieties and hybrids. There is ample scope of developing hybrid Ideotype in crops like maize, sorghum, pearl millet and rice. China has developed hybrid rice for commercial which covers more than 18 million hectares.
3. Crop Ideotype have been developed in cereals and millets. There is ample scope for developing ideal plants or models plants in pulses, oilseeds, cotton and several other field crops. In these crops, again Ideotype have to be evolved both for irrigated as well as rainfed cultivation. In cotton, Ideotype have to be developed for regard to agroclimatic conditions.
4. In addition to traditional breeding approaches, biotechnological approaches, especially tissue culture and protoplast technology, have to be utilized in future for designing new plant types. Biotechnology may help in the development of insect resistant cultivars through the use of transgenic plants.
5. Development of crop Ideotype is a continuous process, Ideotype is a moving goal which changes with advancement in knowledge, new requirements, change in economic policy, etc.
6. Ideotype should be developed to adverse condition such as heat cold, salinity, and drought conditions.

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Smart Crop Production in Climate Change Scenario

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Climate change is a major theme of discussion nowadays everywhere. Climate change is not a one-day matter but gradual changes have been noticed. The changes are rainfall pattern, rainfall intensity, cloud burst, unpredictable floods in non-flooding areas, increase in temperature as well as drought. For farmers, it is very unpredictable matter as they have to go for seasonal crops and depends on climate only. As most of the area in India are rainfed.

In rural areas of developing countries, more than 70% of the population still depends on agriculture. However, economic crises, unscientific land allocation and climate change issues have hindered attempted gains in agricultural productivity and related rural development outcomes. Technology-driven breakthrough has usually pushed agriculture to the brink of another development that can affect not only plant diversity and yield, but also climatological and socio-economic outcomes. The concept of sustainable agriculture has become increasingly popularized as research and farming communities believe that productivity with environmental and social consequences need to be judiciously balanced. Agriculture of developed nations has practically benefitted of this concept worldwide during the 1990 s. In order to be successful worldwide, extensive research must be conducted not only for large-scale farms in developed nations but also for small-scale farms in developing nations.

As we know greenhouse gas is the major factor of climate change. Due to increase concentration of concentration of greenhouse gas in the atmosphere, due to increase of human activity that led to enhanced greenhouse gas effect. Resulted increase heat on earth's surface.

Climate change has many effects on agriculture crop production that led to threat to food security against increased population. Agriculture on the other hand also one of the contributors of greenhouse gas (CO_2, N_2O, CH_4, CFCS).

In present scenario of agriculture, needs both adopt to the climate change effect and also has to reduce the GHG emissions via different ways. Due to climate change so many effects have been found in production of crop, adaptability of different varieties. So, adoption mechanism has to adopt to cope with the adverse situation.

Climate smart agriculture is an action to meet the changes of climate change to get the agricultural product to meet food security. The related factors of climate change adaptation, mitigation and productivity, and increase in income are the factors that depend on each other.

Many climates resilient measures have been worked out by scientists, and researchers as climate-smart agriculture.

For every good production quality of seed is important along with other types of planting material. In this case seed delivery system and agricultural extension system should be strengthened.

The technologies for climate smart agriculture are- the use of quality seeds and planting materials, integrated pest management, sustainable mechanisms, improved water use & management, sustainable soil, and land management, biodiversity management, and technology for decision-making. As per FAO (2011), using quality seeds and planting materials, including rootstock and scion combinations, of well-adapted varieties is good agricultural practice and is climate-smart. Choosing crop species and varieties adapted to the prevalent or expected impacts of climate change for the given region and farming system is the most economical and environmentally friendly means of safeguarding crops against abiotic and/or biotic stresses, such as climate-driven extreme weather events and upsurges in pests and diseases. Useful traits include time to ripening, early and late maturity, blooming, and resistance to pests and diseases.

Promoting intra- and inter-specific diversity over space (e.g., intercropping, using crop variety mixtures) and/or time (e.g. crop rotations) increases the stability of crop yields. Crop associations and rotations designed for specific adaptation goals use cover crops to partially or entirely replace mineral fertilizer inputs, and/or mechanical soil tillage. In climate-smart systems, the main function of cover crops is not necessarily seed production. Cover crops need to be terminated when appropriate to achieve the agronomic goal they are designed for. Growing a single crop, using a mixture of appropriately chosen genotypes of a given species, such as a mixture of high-yielding hybrid varieties and traditional varieties, increases the producer's resilience in the face of climate unpredictability. Growing annual crops (e.g. leguminous crops) in the rows between perennial crops requires the accurate selection of species to avoid competition for water in the most vulnerable phenological stages.

The proper interpretation of reliable seasonal forecasts allows farmers to select crop varieties and to adapt crop calendars to new temperatures and rainfall patterns, plan the timing of husbandry operations, such as irrigation; pruning to avoid damage from heat or moisture; fruit thinning to balance excessively high rates of fruit set and reduce competition for developing fruit in case of excessive flowering; protecting early bloom from late frosts through short-term interventions. Implementing soil and water conservation techniques or in situ water conservation (e.g. soil mulching, rainwater harvesting) enhances crop productivity.

Inducing flower by spraying or by irrigation is a short-term intervention to break dormancy when natural climate phenomena for breaking dormancy are absent. Shading and/or painting trunks decrease the effect of excessive sun and heat. Misting helps control both freezing temperatures and heat.

Measures aiming at preventing crop losses may include: Selecting species capable of resisting specific extreme weather conditions (e.g., root and tuber crops in cyclone-prone areas) or species with short growing cycles from seed to yield.

Protecting crops with: mulch of different materials and colours, for controlling weeds and reducing evapotranspiration; nets, for bird control, insect proofing, hail protection and shading; floating mulch for protection against late frost and insects

Different submergence-tolerant rice varieties like Ranji Sub 1, Swarna Sub 1, Bahadur Sub 1, Cheherang Sub 1, IF 64 Sub 1 etc can cope the resilience of climate change. Just like that the white cabbage variety is also suited to adverse climatic condition.

Increasing efficiency in fertilizer use through site-specific nutrient management practices that optimize the use of existing soil nutrients while filling deficits with mineral fertilizers.

Using conservation agriculture improves soil health, allows the soil to grow both at the surface and at depths, and improves water retention.

Minimizing mechanical soil disturbance continuously over time prevents and soil compaction, slows the mineralization of soil organic carbon, increases the effectiveness of rainfall, curbs soil erosion and reduces the risks of waterlogging. The year-round seeding of fields in crops/mulch, if water availability permits, protects the soil from erosion and compaction, and keeps important nutrients, especially nitrogen and phosphorus, on farmers' fields.

Most nutrient losses occur during the period between seeding and the development of a dense canopy; and after harvest when there is no crop on the field.

A diversified and intensive crop rotation is one that: eliminates fallow periods where possible; returns crop residues to the soil with an average carbon-to-nitrogen ratio in the 25-30 range; improves the soil and responds to specific needs related to agronomic practices (e.g. improved soil compaction) and water management either through improved drainage or reduced evaporation.

Integrating nitrogen-fixing perennial woody species (e.g. *Cajanus cajan* or pigeon pea) and trees with annual crops increases soil fertility, produces biomass and reduces soil erosion. This practice also sequesters carbon and redistributes the carbon to deeper soil layers. Integrating multipurpose crop varieties, whose biomass can be used in a range of combinations for food, biofuel, feed, and/or fibre, can improve the functional and productive management on the farm and be climate-smart. Examples of multifunctional crops include living fences that can provide food and feed and serve as windbreaks.

Crop water productivity is improved by implementing good agronomic management decisions and practices such as selecting crop varieties that are drought tolerant and/or have a higher water productivity (i.e., that deliver more yield per liter of water); adjusting cropping calendars; encouraging deeper rooting of crops; using conservation agriculture for higher water retention; and mulching.

Implementing soil and water conservation techniques (e.g., soil mulching, shading, rainwater harvesting, using fences or windbreaks to reduce evaporation) enhances crop productivity.

Integrating feed for livestock from annual crops with perennial feed, particularly from deep-rooting legumes, promotes soil health and provides additional quality forage during dry periods. It also improves the quality of the diet of ruminants, reducing methane emissions from enteric fermentation.

In irrigated systems, increasing the efficiency of irrigation (e.g., through deficit irrigation, precise water applications, high-efficiency pumps), reducing water losses and improving water allocation and the management of water demand, optimizes yields per volume of water applied, reduces greenhouse gas emissions and brings about gains in energy efficiency, mainly in the use of fuel.

For increases in the quantity, frequency, and intensity of rainfall, the following practices reduce or avoid damage to roots from waterlogging: Improving drainage.

In the case of biodiversity management, growing "a genetically diverse portfolio of improved crop varieties, suited to a range of agro-ecosystems and farming practices, and resilient to climate change" is a validated means for enhancing the resilience of production systems (FAO, 2011). When confronting abiotic changes (e.g. shifting rainfall and temperature patterns) and biotic disturbances (e.g. pest infestations), the level of existing biodiversity can make the difference between a stressed agricultural ecosystem and a resilient one.

The diversification of crop systems can take many forms, involving different crop species and/or varieties (intra- and/or inter-specific diversification), different spatial scales (landscape, farm, individual fields and/or crop) and different time frames.

In case of Integrated Pest Management, climate change will affect the spread and establishment of a wide range of insect pests, diseases and weeds. Integrated pest management is an ecosystem approach to crop production and protection. It is based on the careful consideration of all available pest management techniques. Integrated pest management involves the use of appropriate measures to discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified; reduce or minimize risks to human health and the environment; and disrupt as little as possible the agricultural ecosystem. As the climate changes, national regulatory, policy and institutional frameworks must be strengthened to enable the adoption of integrated pest management practices on farms and in rural communities. In particular, frameworks should support farmer training in integrated pest management; maintain the surveillance systems, including those used in community groups, that are used to detect and report changes in the behaviours of pests and natural enemies; develop appropriate quarantine procedures to prevent the entry and establishment of plant pests; and formulate appropriate management strategies to respond to potential outbreaks. Other important elements of any strategy to promote a shift to resilient crop production systems include phytosanitary frameworks and measures that can facilitate the creation of markets for sustainable products; and the transparent collaboration among policy makers, industries and farmers on the national registration processes for the most appropriate pesticides to a climate-smart approach (FAO & INRA, 2016).

Sustainable soil and land management for increased crop productivity where at the landscape level, reducing land-use change by carefully limiting the need to expand cropland and grazing land can reduce emissions and increase the capacity of the soil to store carbon.

At the field level, increasing productivity allows to grow more from the land already under production. This eliminates the need to open new land for agriculture and helps reduce the emissions associated with agricultural expansion. Soil protection can be achieved by practicing direct seeding in combination with the sustainable management of crop residues and within a broader framework of integrated soil fertility management.

Sustainable mechanization where the availability of appropriate machinery to carry out sustainable crop management practices increases productivity per unit of land. It also increases efficiency in the various production and processing operations and in the production, extraction and transport of agricultural inputs, including coal and oil.

Technologies for decision-making where developing simple and robust scientific tools that can guide the decision-making of farmers on a seasonal and long-term basis is essential for planning strategies to address climate change.

In terms of risk management, some of the most relevant technologies relate to weather forecasting and early warning systems. The improved timing and reliability of seasonal forecasts and hydrological monitoring enables farmers to make better use of climate information, take pre-emptive actions and minimize the impact of extreme events (Faurès et al., 2010; Gommes et al., 2010).

Conclusion

Crop production in climate change environment is therefore inclusion of many technologies than normal crop production practices. Farmers have to be award to know the technologies in proper way so that they can be able to cope with adverse climatic situations. FAO has played a great role in the climate-smart agriculture by providing many more informations.

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Cropping System for Sustainable Agriculture Under Red-Laterite Zone

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There is currently a demand to grow more crops in less area as a result of urbanization's reduction of agricultural land. As a result, soil fertility is gradually declining. To maintain soil fertility, various management methods are used in modern times. Agriculture is undoubtedly the backbone of any developing country like India. It is the prime source of food-fodder-fibre-fuel-fruit-flower-fish and timber and provides raw materials to many large- and small-scale industries. A lion's share of the country's mammoth population depends directly or indirectly on agriculture. Being the largest private enterprise in India it contributes 17.6% of national GDP. The green revolution in mid-sixties, steered by research based new technological development involving new materials, methods and ways of organizing farm inputs and the government policy, transformed the agriculture dramatically. As a result, the output exhibited manifold increase in production and productivity. But this development is not spread through-out the country in equal manner. The red and lateritic zone (RLZ) of Eastern India comprised of South-West West Bengal, western Odisha and almost entire state of Jahrkhand. It occupies dismally a low position in respect of yield levels in comparison to many other parts of the country. The dismal situation regarding the low position in respect of yield levels is attributed to poor input use efficiency, soil degradation such as erosion, decline of soil organic carbon content, nitrate transfer to ground and surface water, biodiversity erosion and above all, deceleration of total factor productivity. Suitable and time bound cropping system become an important factor for higher crop production per unit area of this region. A cropping system refers to the type and sequence of crops grown and practices used for growing them. It encompasses all cropping sequences practiced over space and time based on the available technologies of crop production. This is an integrated part of farming system which is a set of activities that farmers execute in their farms under their resources and circumstances to maximize the productivity and net farm income on a sustainable basis. This is considered a powerful tool for natural and crop resource management in extreme rainfed and drought prone area of developing countries such as India. Cropping system under farming system, a multi-disciplinary whole-farm approach and very effective in solving the problems of small and marginal farmers particularly in red-latertic belt of west bengal and adjoining state. The approach aims at increasing income and employment from small-holdings by integrating various farm enterprises and recycling crop residues and by-products within the farm itself. The need for cropping systems in the present scenario is mainly due to high cost of farm inputs, fluctuation in the market price of farm produce, risk in crop harvest due to climatic vagaries and biotic factors. Environmental degradation, depletion in soil fertility and productivity, unstable income of the farmer, fragmentation of holdings and low standard of living add to the intensity of the problem. Cropping systems have been traditionally structured to maximize crop yields. Now, there is a strong need to design cropping systems which take into consideration the emerging social, economic, and ecological or environmental concerns. Conserving soil and water and maintaining long-term soil productivity depend largely on the management of cropping systems, which influence the magnitude of soil erosion and soil organic matter dynamics. While highly degraded lands may require the land conversion to non-agricultural systems (e.g., forest, perennial grass) for their restoration, prudently chosen and properly managed cropping systems can maintain or even improve soil productivity and restore moderately degraded lands by improving soil resilience. The soil and agro-climatic conditions of the red and lateritic belt are unique, and the rice-based cropping system is predominant in the region. The improvement of irrigation facilities and adaptation of HYVs and hybrids attracted farmers to adopt a rice–rice cropping system. Crop diversification is an important option in sustainable agricultural systems.

Cropping system and sustainable agriculture

As the world population, particularly that of developing countries, is increasing with an alarming rate, there is a pressure on the agriculturists to continue to feed this ever-increasing population. But during recent year, the productivity has remained stagnant and, in many cases, a gradual decline has been observed. More over the indiscriminate use of chemical fertilizer and pesticides have posed a new threat to the environment and soil ecosystem. Arsenic problem in few pockets of West Bengal and other parts of India is a good example. In our mind few questions raised that, how we can conserve the natural ecosystem without further decline in productivity and ecological situation. Good cropping systems with effective sustainable agriculture become a good answer. Sustainable agriculture as such is the successful management of resources for agriculture to satisfied changing to human needs while maintaining or enhancing the quality of environment and conserving natural resources. The modern agricultural practices which are heavily dependent on the use of chemical pesticides, inorganic fertilizers and growth regulators has raised the agricultural production manifold but at the cost of resource depletion, environmental deterioration and loss of crop diversity. Therefore it was realized that the modern agriculture is not sustainable in long run, hence the concept of effective cropping system with sustainable agriculture practice emerged, which not only emphasizes on the conservation of the natural resources but also maintains the quality of environment with effective cropping pattern etc. Sustainable agriculture is a holistic approach having many facts. One of them is cropping systems, a non-input resource which may lead to sustainable agriculture. Intensification of Rice-fallow in red-laterite belt by inclusion of suitable crops was one the major challenges due to very limited options for introduction of new crops. But, in recent times, cropping system intensification by pulses is facing a bit impediment due to ill impacts of climate change like rising temperatures, unpredictable monsoons as well as severe disease pest infestation. Venture with vegetables has already shown the troubles related to availability of enough water during post monsoon seasons in RLZ. The landscape of this region is mostly undulating with drainage lines and land near streams comprising lowlands (‘*bohal*’) which rise to local uplands (‘*tanr*’) with relief typically <30 m. Hydrologically, uplands are recharge areas whereas lowlands are local discharge areas for seasonally recharged shallow ground-water (Brahmachari *et al*., 2019). The narrow band of medium lowlands (‘*kanali*’) between them is a discharge area. The east India plateau is characterized by endemic poverty, food insecurity, comparatively low agricultural productivity and lack of irrigation infrastructure. Rice is the staple food crop and traditional cropping is typically mono-cropped rice production. *Bohal* is generally used for cultivation of rice. But with the increasing food demand, the medium uplands (‘*baid*’) of this region is now extensively used for rice cultivation. The region receives a high amount of rainfall with “low productivity” because soils are acid and infertile with low water holding capacity (Manivannan *et al*., 2017). For this, cultivation of rice in medium uplands is risky job and poorly suited to traditional rice production systems of this RLZ. Intensification of Rice-fallow in red-laterite belt by inclusion of suitable crops was one the major challenges due to very limited options for introduction of new crops (Brahmachari *et al*., 2019).

Intensification of existing cropping system of RLZ of eastern India needs a holistic approach from selection of land to value addition of final products. The existing cropping system in RLZ is mainly rice based where the farmer generally seeds rice at the onset of monsoon and reaps the harvest at the beginning of winter. Most of the land here remains fallow due to various biophysical constraints like high evapo-transpiration during summer and winter, meagre soil fertility and water holding capacity, erratic rainfall and less adoption of modern agro-techniques by the resource challenged peasants. Depending on the resources and technology available, different types of cropping systems may be adopt as per limitation of cultivation in different field, these are:

- **Monocropping or single cropping:** Mono-cropping refers to growing only one crop on a particular land year after year or practice of growing only one crop in a piece of land year after year e.g., growing only rabbi crops in dry lands or only said crops in diary lands (Lands situated in river basins which often remain flooded during rainy season). This is due to climatologically and socio-economic conditions or due to specialization of a farmer in growing a particular crop. Groundnut or cotton or sorghum is grown year due to limitation of rainfall. Flue-cured tobacco is grown in Günter (A.P.) due to specialization of a farmer in growing a particular crop. Rice crop is grown, as it is not possible to grow any other crops, in canal irrigated areas, and under water logged conditions.

- **Multiple cropping or poly cropping:** It is a cropping system where two or three crops are gown annually on the same piece of land using high input without affecting basic fertility of the soil. It is the intensification of cropping in time and space dimensions i.e. more number of crops within a year and more number of crops on the same piece of land at any given period. It includes inter-cropping, mixed cropping and sequence cropping. Under present context multiples cropping is a philosophy of maximum crop production per acre of land with minimum of soil deterioration. Few examples are:
- Rice-potato-green gram.
- Rice-mustard-maize.
- Rice-potato-sesame.
- Jute-rice-potato.

These patterns of cropping system should be very sound, so that we could sustain our soil and environment health without compromising per unit productivity and farmer or growers' income. Some of the areas where cropping system can be very effective component of sustainable agriculture, are mainly crop diversification, pest and disease management, nitrate pollution management, tillage and seed bed preparation management, water and nutrient management.

Crop diversification

Crop diversification is important factor for enhancing crop production and maintaining the sustainability. Crop rotation, mixed cropping and intensive cropping is the methods of crop diversification which not only enhances yield but also reduce the erosion. Crop rotation which refers to the alternate growing of crops is important for successful sustainable farming (Mukherjee, 2022). Crop rotation practices are not only important for soil fertility management but are also helpful in weed, pest and disease control. In any rotation, leguminous crops are essential for nitrogen supplement to the soil. Mixed cropping with leguminous crops increases the yield of non-leguminous crop therefore it is necessary for the success of sustainable agriculture. In intensive cropping a number of crops are grown simultaneously in the same piece of land in one agricultural year. Multiple cropping and relay cropping are the examples of intensive cropping.

Cropping system for disease, pest and weed management

Adoption of improved cropping system has considerably reduced the use of pesticides. In modern agriculture practices the over use of chemical pesticides has led to the problem of pesticide resistance and pest resurgence. Besides this, many of the pesticides are non-biodegradable causing the problem of environmental pollution. This has led to the emergence of the concept of Integrated Pest Management (IPM). It refers to an ecological approach of pest management in which all available necessary techniques are practiced in a unified programme so that pest population can be managed in such a manner that economic damage is averted and adverse effects are minimized. It includes mechanical, physical, cultural, biological and chemical methods. In addition to these methods, sometimes friendly insects and spiders are also encouraged. Spiders are farmer friendly as they destroy pests in many crops especially rice. Most common of them are wolf spider, sack spider, diver spider, orb spider and the jumping spider. Besides these, botanical pesticides (derived from plants) are used to control the pests and diseases. A pigeonpea + sorgum intercropping system extensively practices in Karnataka, Maharashtra and Andhra Pradesh has considerably decreased the incidence of root rot of cotton due to *Rhizoctonia solani*. Similarly, incidence of top borer in sugarcane was greatly reduced when coriander was intercropped with sugarcane.

Weed control include cultural, physical, biological and chemical methods. In sustainable agriculture cultural, physical and biological methods are at priority. Weeds are generally controlled by rotation, tillage and hand-weeding (Mukherjee, 2005). Chemical weedicides are also used to control the weeds if the above methods fail to overcome the problem of weeds. However, in sustainable agriculture weeds are often tolerated and encouraged up to some extent as weeds play valuable function like nutrient cycling, disease and pest control, soil and moisture conservation and organic matter improvement as green manure. Jonson grass (*Sorghum helpense*) a predominant weed in continuous maize cultivation was controlled by rotating with cotton. Similarly, nut grass biomass was reduced in sesame – wheat followed by sesame – wheat –green gram as compared to pigeonpea wheat , greengram sequence (Bhan *et al*. 1998). In maize – potato cropping system growing of purlemllet or sesame (for green manure) during summer was found effective in reducing *Cyperus rotendus* population is succeeding maize and potato. Intercropping systems have also been found to suppress weeds through formation of canopies due to competitive planting pattern and thus provide an opportunity to utilize cropping system as a tool in weed management with non-chemical means. Pigeonpea + sorghum intercropping system which is extensively practiced in Karnataka, Maharashtra and Andhra Pradesh is known to reduce weed intensity apart from efficient land utilization. It is also reported that inter cropping systems based on sorghum reduced weed growth by 25% more efficiently than sole crop system.

Nitrate pollution management

Pollution of ground water owing to leaching of nitrates is relatively a new concern in India. At such low rates of N-fertilizer use prevalent in the country, nitrate leaching is not likely to pose serious problems in most farming situations. However, increase in NO_3-N content of shallow wells has been registered in the areas where heavily fertilized and irrigated cropping systems predominate. In Ludhiana district of Punjab, average NO_3-content of shallow wells increased from 0.42 to 2.29 mg/litre during 1975-88 (Reddy, 1999). Fertilizer management practice, season, frequency and depth of irrigation, depth of the soil and rooting pattern of crops are most important factors influencing nitrate pollution. The same increased rapidly with increasing use of N fertilizers. Choice of appropriate cropping systems and management practices minimize nitrate leaching besides improving N use efficiency. Legume inter cropping in cereals grown with wider row reduces nitrate leaching. Parallel multiple cropping (a system of growing crops having variable growth habit with minimum competition) of sugarcane and black gram and that of pigeonpea and maize resulted in low NO_3-N content in soil profile as compared to sole cropping. As a crop management strategy to minimize NO_3 leaching it has been suggested to delay large amount of N applications until the crop can utilize it and to avoid irrigation when large amounts of NO_3-N is present in the root zone.

Conservation tillage

Tillage practices in sustainable agriculture aims at reducing soil degradation and losses by erosion. A common way is to provide optimal condition for beneficial soil organisms, thereby enhancing organic matter decomposition and nutrient cycling. Managing the top 8 cm of soil is vital because most of the biological activity, micro-organisms and organic matter are found in this soil layer. Therefore, conservation tillage is adopted in place of conventional tillage under major cropping system. Conservation tillage is disturbing the soil to the minimum extent necessary and leaving crop residues on the soil. Minimum tillage and Zero tillage are the types of conservation tillage which reduce soil loss up to 99% over convention tillage (Mukherjee, 2013). In minimum tillage, the tillage practices are reduced to minimum extent for ensuring (improved soil condition due to decomposition of plant residues in situ) a good seed bed, rapid germination and favourable growing condition, whereas the zero tillage is an extreme form of minimum tillage where primary tillage (opening of the compact soil with the help of different ploughs) is completely avoided and secondary tillage (lighter or finer operations performed an the soil after primary tillage) is confined to seed bed preparation in the row zone only. Zero tilled soils are homogenous in structure with more number of earthworms. There is increase in organic matter content due to less mineralization. Surface runoff is reduced owing to presence of mulch. In most cases, conservation tillage reduces soil loss by 50% over conventional tillage. Moreover, conservation tillage maintains the organic matter content of the soil and prevents the removal of nutrients from soil through rainwater. Conservation tillage also causes an increase in microbial and earthworms' population in the soil. In rice-wheat system high intensity deep puddling has been found to reduce drainage losses of water and fertilizer nutrients and favour rice growth in most soils (Saha *et al.*, 2023). However, destruction of soil aggregates due to puddling in rice results in poor tilth, and increased soil strength in surface sub-surface layers, decrease hydraulic conductivity and infiltration and inadequate charging of the soil profile for the crop following rice. These unfavorable soil conditions reduce yield of wheat following rice than that following maize. Wheat rooting is often restricted in soils after puddling rice, which is also attributable to reduced sub-surface layers, which continue to remain wet and anaerobic long after the harvest of submerged puddled paddy. In coarse soils, tillage for rice-wheat sequence may be optimized by high intensity puddling for rice and high intensity shallow tillage for wheat, as deep tillage for the latter resulted in higher drainage losses of water and fertilizers. In maize-wheat system, some agronomists have reported better root development with deep ploughings (45cms) in a sandy loam alluvial soil, resulting in higher grain of maize as well as wheat, compared to 25 cm ploughings. Varying the number of tillage operations either in maize or wheat did not produce significant differences in the yields. However, repeated tillage increased cost of cultivation and thereby, reduced net return to the system. In vertisols rainy season sorghum + pigeon pea inter cropping system, as shallow tillage enable storage of more soil water than traditional flat bad fallow. Adoption of zero tillage play vital role for sustaining agricultural productivity in favorable soil system.

Water management through efficient cropping system

Water management is key to the success of sustainable agriculture under various cropping system in India and particularly in West Bengal, as water is an important natural resource. Water management can be divided into rain water management and irrigation water management. The important aspects of rain water management are water harvesting, supplemental irrigation and reduction of evapo-transpiration. Irrigation water management involves scheduling irrigation at appropriate time with adequate quantity of water without causing water logging, soil salinity and alkalinity. Irrigation water is a costly and scarce resource and its availability for agriculture is expected to further go down due to increase by generic and environment manipulation of the crops, it can also be increased by decreasing the evapo-transpiration and other losses of water, such as conveyance, application, water use efficiency which can be increased by identification of appropriate crop combinations in various system. More remunerative and less water consuming crop rotations have been standardized at different locations in the country. Agronomists have found that rice-potato-green gram rotations were more viable sequences under lesser water input at Memgri in west Bengal. At Kharagupur, rice-wheat, rice-mustard and rice-potato were viable sequences under lesser input (Mukherjee, 2019). Substitution of sugarcane, which is high water demanding crop for Maharashtra, it was found that per-monsoom groundnut – rabi sorghum sequence was not only highly remunerative (Rs.23,100 net returns) with a cost: benefit ratio of 1:2.9 but also highest water expense efficient (342 mm/ha) as well as production efficient (Rs.96/ha/day) (Yadav *et al.*, 1998). Under limited water supply, however, rice-gram-green gram and rice-mustard-green gram have been found suitable. In north western plains, under annual supply of 10 irrigation, maize-wheat system gives the maximum net returns with minimum water expense. Maize + cowpea (fodder) – toria-wheat system followed it closely. Based on research, during last 50 years it has been established that culture of crops such as legumes which have dense canopy and deep root system, green manure crops and densely populated crops, during rainy season reduced soil and water losses to significant extent. In that context, alley cropping for adding foliage as organic mulch to conserve moisture holds promise in sorghum (F) – wheat rotation. Studies on moisture conservation at Jodhpur on shallow loam soil receiving bunding increased soil moisture content by 50 to 75% (Yadav *et al.*, 1998).

Nutrient management through efficient cropping schemes

Indiscriminate use of chemical fertilizers in modern agriculture to enhance the crop yield has abused the land resources resulting into stagnation in food grain production. Therefore Integrated Nutrient Management (INM) is key to success of sustainable agriculture. Integrated nutrient management which emphasizes on the use of renewable sources of nutrients ameliorates the soil health in long run (Mukherjee, 2014). Therefore, it ensures the concept of sustainability in agriculture. In integrated nutrient management all the possible sources of nutrients are applied based on economic consideration and the balance required for the crop is supplemented with chemical fertilizers. The sources include manures, green manures, compost, vermin-compost, bio-fertilizers and concentrated organic manures. Organic fertilizers have a slower action but they supply available nitrogen over a longer period of time. Moreover, they protect useful flora and fauna of the soil, ameliorate yields and quality of products. Since there is increase in soil fertility the biological activity is maintained intact. Based on results of Long Term Fertilizer Experiments, which have been reviewed recently and information generated under cropping systems and other scattered studies a few examples are cited below how the efficiency of nitrogen, phosphorous and potassium have been increased through efficient cropping system (Reddy, 1999). In rice – potato-jute sequence, fiber yield increased markedly due to residual effect left after potato (Mukherjee, 2021). Further, at Kalyani in Rice-Potato sequence 100 kg N applied to either of the crops left residual effect equivalent to 25 and 33% of its direct effect in potato and rice, respectively on the alluvial soil. Since plant species vary in their capacity to utilize native and fertilizer P, and leave differential amount of residual P, suitable cropping pattern designing is important. In rice-wheat system, as the distinct growing environment of these crops allowed for a greater adjustment of P application rates. Solution P increased under low land rice culture owing to submergence and high temperature, though the magnitude varied widely in different soils (Mukherjee and Mandal, 2017). Because of this phenomenon, wheat responded tremendously to apply P while relatively lower response was observed in rice on the same piece of land. It has also been reported that 60kg P_2O_2/ha applied to wheat in alluvial soils of Punjab was sufficient to meet requirement of both the crops in rice – wheat system. However, later studies in Punjab indicated superiority of direct application of 30kg P_2O_2/ha each to rice and wheat over 60kg P_2O_2/ha to either of the crops (Bhan *et al*., 1998). In view of these results, it may be concluded that adjustment of P in cropping system should not be made without specifying the soil characteristics, nature of crops in the system, their yield level , growing environment and type of fertilizers used. Nevertheless, under resource constraints, P application to wheat may be preferred over rice in rice-wheat system on marginally deficit soils. Soils highly deficit in P are exceptions where all the crops in the system may require P application at recommended. Removal of K in proportion to N is very high in cropping system particularly in those involving cereals and fodder crops. Unfortunately, application of K has not been received due attention, as most Indian soils were considered adequate in native K supply (Mukherjee, 2014 a). But due to continuous rice – wheat cropping system and multiple cropping there is severe mining of K too. In jute growing areas where rice potato jute is a common cropping system, potato suffer more K deficiency. Use of fertilizer in potato and allowing jute to meet its K demand through residual effect was found beneficial in these areas. In rice- wheat –jute system too jute received benefit from K applied to preceding rice and wheat.

Conclusion

Suitable cropping system under different zone of India in sustainable manner does not impose any harm to environment, biodiversity, and quality of agricultural crops. Producing crops sustainably increases the ability of the system to maintain stable levels of food production and quality for long term without increasing the demand and requirements of agricultural chemical inputs to control the system. Sustainable crop production deals with keeping the soil alive with organic matter, integrated pest management and reduction in usage of pesticides, protecting biodiversity, ensuring food safety and food quality, improving nutrient quality, and fertilizing the soil with organic fertilizers. This leads to lowering of greenhouse gas emission and carbon footprint of overall world. Sustainable usage of resources ensures the pollution-free environment for our future generations.

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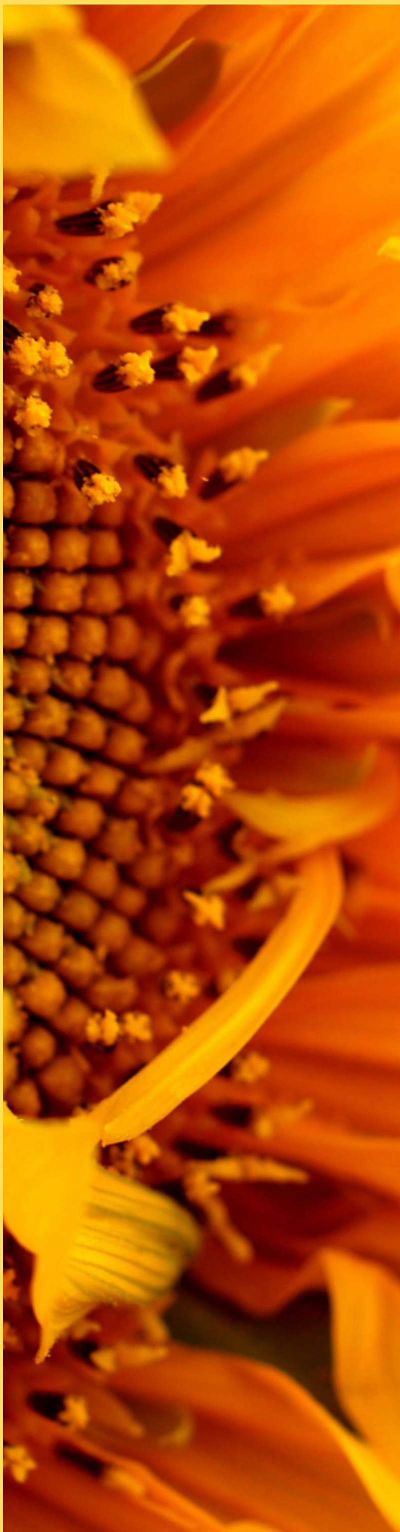

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