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In This Issue

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Carbon Finance: A Catalyst for Climate-Resilient Agriculture and Biodiversity Conservation

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Introduction

In recent years, the agricultural sector has faced increasingly severe challenges posed by climate change. Erratic weather patterns, extreme temperaturesand unpredictable precipitation have disrupted traditional farming practices, jeopardizing global food security. In response, there has been a growing recognition of the need to implement sustainable practices that not only mitigate climate risks but also contribute to reducing greenhouse gas emissions. Carbon finance presents a promising avenue for incentivizing such practices, offering financial rewards to farmers who adopt climate-smart techniques.Due to the possibility of utilizing carbon markets and bilateral and multilateral support to leverage climate finance, developing nations, their development partners, and other stakeholders are attempting to operationalize the idea of NAMA's. According to Sawyer, Dion, Murphy, Harris and Steibert (2013), NAMA's are increasingly being used as a primary planning tool by developing nations that want to voluntarily undertake GHG mitigation measures in support of sustainable development.The amount of money needed for INDC agriculture adaptation and mitigation actions exceeds the amount of money allocated for this purpose by a significant margin. In December 2015, an initial study of INDCs found that significant additional funding would be required to meet the climate targets that less-developed nations had set for agriculture (Richards *et.al.*, 2015). In this article, we explore the potential of carbon finance in agriculture towards climate risk mitigation.

Carbon Finance in Agriculture

Carbon finance involves the trading of carbon credits, which represent the reduction or removal of greenhouse gas emissions. In agriculture, carbon credits can be generated through various practices that sequester carbon dioxide from the atmosphere or reduce emissions of other greenhouse gases such as methane and nitrous oxide. These practices include conservation tillage, agroforestry, cover cropping, rotational grazing and the adoption of organic farming methods. According to GSMA (2015), these services are currently available in 93 countries and provide 271 services in total.

Transitioning towards Climate-Smart Agriculture

Climate-smart agriculture (CSA) offers a holistic approach to addressing the challenges of climate change while ensuring food security and sustainable development. CSA practices aim to increase agricultural productivity, enhance resilience to climate variability and reduce greenhouse gas emissions. By integrating carbon finance into CSA initiatives, farmers can be incentivized to adopt practices that not only benefit the environment but also improve their livelihoods.

Benefits of Carbon Finance for Agricultural Climate Risk Mitigation

Financial Incentives: Carbon finance provides financial rewards to farmers for implementing climate-smart practices, thereby offsetting the costs of adoption and incentivizing sustainable land management.

Improved Soil Health: Many CSA practices, such as conservation tillage and cover cropping, enhance soil health by increasing organic matter content, improving water retention and reducing erosion. Healthy soils act as a carbon sink, sequestering carbon dioxide from the atmosphere and mitigating climate change.

Enhanced Resilience: Climate-smart practices help farmers adapt to changing climatic conditions by diversifying crops, improving water management and conserving natural resources. By building resilience, farmers can better withstand extreme weather events and minimize crop losses.

Biodiversity Conservation: Agroforestry and mixed cropping systems promote biodiversity by providing habitat for wildlife, conserving native plant species, and restoring degraded landscapes. Biodiverse agricultural systems are more resilient to pests, diseases and environmental stresses, contributing to long-term sustainability.

Challenges and Opportunities

While carbon finance holds great potential for agricultural climate risk mitigation, several challenges must be addressed to realize its benefits fully. These include:

Measurement and Verification: Accurately quantifying carbon sequestration and emission reductions from agricultural practices can be complex and costly. Robust monitoring, reporting and verification (MRV) systems are needed to ensure the integrity of carbon finance transactions and prevent fraud.

Access to Markets: Smallholder farmers, who often lack access to markets, technology and finance, may face barriers to participating in carbon finance schemes. Mechanisms such as carbon aggregation and project bundling can help smallholders overcome these barriers and access carbon markets.

Policy Support: Governments play a crucial role in creating an enabling environment for carbon finance in agriculture through supportive policies, incentives, and regulations. Policy coherence across sectors is essential to mainstreaming CSA and integrating carbon finance into national climate strategies.

Knowledge and Capacity Building: Building the capacity of farmers, extension services, and other stakeholders is essential for the successful implementation of climate-smart practices and carbon finance initiatives. Training programs, technical assistance and knowledge-sharing platforms can facilitate the adoption of best practices and promote innovation.

Conclusion

Harnessing carbon finance for agricultural climate risk mitigation offers a win-win solution for farmers, the environment, and society at large. By incentivizing the adoption of climate-smart practices, carbon finance can help build resilience, improve livelihoods, and mitigate greenhouse gas emissions in the agricultural sector. However, realizing the full potential of carbon finance requires overcoming various challenges, including measurement and verification, market access, policy support, and capacity building. With concerted efforts from governments, civil society, and the private sector, carbon finance can catalyze the transition towards a more sustainable and resilient agricultural system, contributing to global efforts to address climate change.

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Bio-Conversion of Wastes to Edible Mushrooms

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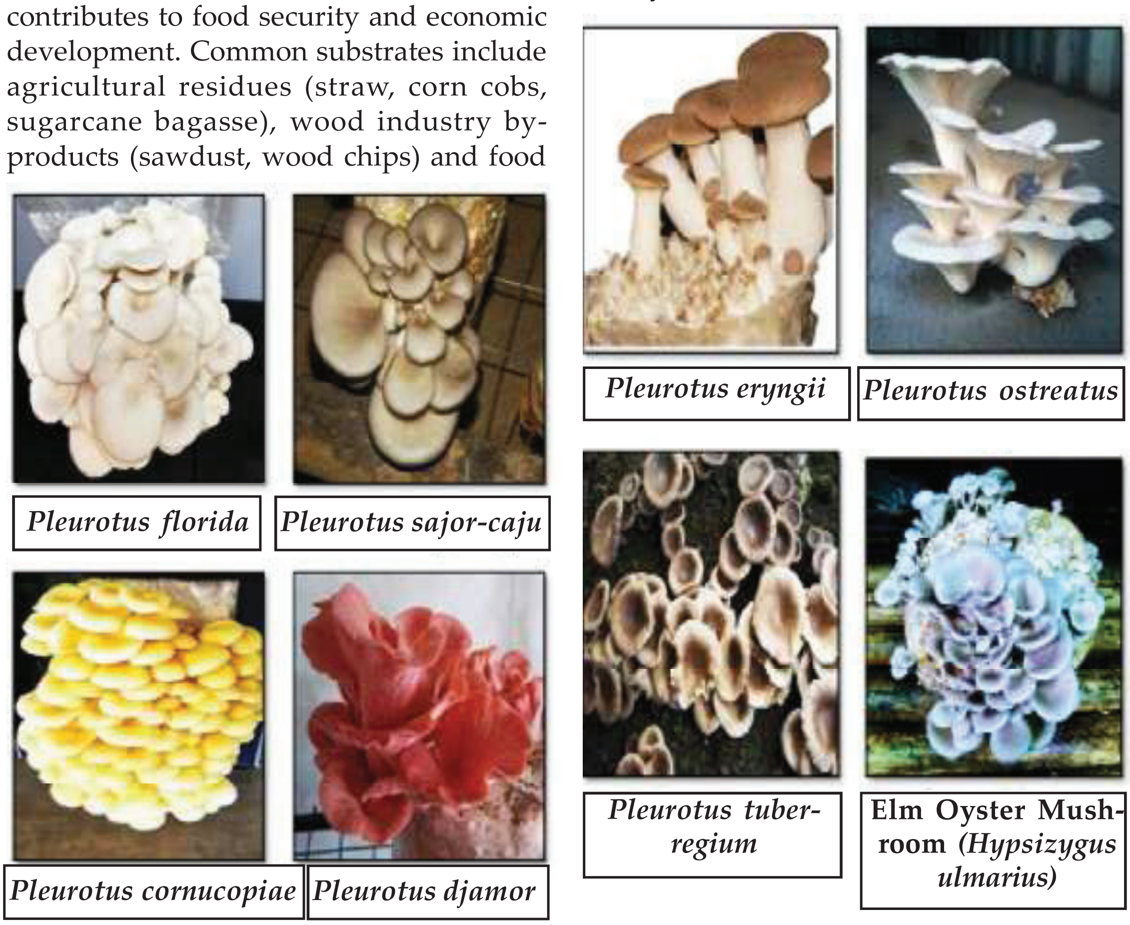
Introduction

The world's population on planet Earth is increasing day by day and is estimated to beover 7 billion. According to some studies, there will be 9 billion people on the planet by 2050 and by 2100, there may be 20 billion of population. Due to urbanization and population growth, there will be a shortage of food, decline in human health and a corresponding decrease in fertile land. One of the most commercially successful and environmentally friendly biotechnology processes is the conversion of lignocellulosic agricultural and forest leftovers into protein-rich mushrooms, which helps meet the world's food demand, particularly for protein and overall nutrition. Waste management is another pressing global issue, exacerbated by the rapid growth of urban populations and industrial activities. Traditional waste disposal methods, such as landfilling and incineration, pose significant environmental hazards, including greenhouse gas emissions, soil and water contamination and loss of valuable materials. Consequently, innovative and sustainable waste management strategies are essential. Waste valorization, the process of converting waste materials into valuable products, offers a promising solution. One such approach involves the cultivation of oyster mushrooms (*Pleurotus* spp.), which not only reduces waste but also produces nutritious food and other valuable by-products (Adebayo *et. al*., 2014). Oyster mushrooms are known for their ability to grow on a wide range of organic substrates, including agricultural and industrial wastes such as agricultural crops straw, sawdust, coffee grounds, vegetable wastes. This adaptability allows for the efficient conversion of waste materials into a valuable protein source. Addressing waste management challenges, the cultivation of oyster mushrooms has several environmental benefits, including reducing landfill use, lowering greenhouse gas emissions and promoting the recycling of organic matter. Economically, this practice can provide additional income streams for farmers and entrepreneurs, while socially, it can contribute to food security and create employment opportunities. Thus, oyster mushroom cultivation represents a sustainable and multifaceted approach to waste valorization, offering significant advantages for environmental health, economic development and community well-being (Aditya *et. al*., 2024a).

The Potential of Oyster Mushrooms

Oyster mushrooms, belonging to the genus Pleurotus, are a diverse group of fungi known for their broad and oyster-shaped basidiocarps (Fig. 1). They are widely cultivated for their culinary and medicinal properties. Oyster mushrooms are known for their adaptability to various substrates, rapid growth and high nutritional value. They are rich in proteins, vitamins, minerals and antioxidants, making them a popular food source worldwide. Additionally, oyster mushrooms possess medicinal properties, including anti-inflammatory, anti-tumor and immune-boosting effects (Bhamberi *et al.*, 2022). The cultivation of oyster mushrooms can utilize agricultural and industrial wastes, such as straw, sawdust, coffee grounds, vegetable wastes etc. These substrates provide the necessary nutrients for mushroom growth, transforming waste materials into a valuable food source. This not only mitigates the environmental impact of waste disposal but also contributes to food security and economic development. Common substrates include agricultural residues (straw, corn cobs, sugarcane bagasse), wood industry by-products (sawdust, wood chips) and food industry wastes (coffee grounds, vegetable wastes). These substrates are rich in cellulose, hemicellulose and lignin, which are complex carbohydrates that can be broken down by mushroom enzymes. Oyster mushrooms convert waste into valuable protein through a series of processes involving the enzymatic breakdown of complex organic materials, mycelial colonization and the formation of fruiting bodies. This bioconversion not only reduces waste but also produces a nutritious food source and valuable by-products, contributing to sustainable waste management and resource utilization (Aditya *et al.*, 2024a).



Pleurotus eryngii | *Pleurotus ostreatus*

Pleurotus florida | *Pleurotus sajor-caju*

Pleurotus tuber-regium | Elm Oyster Mushroom (*Hypsizygus ulmarius)*

Pleurotus cornucopiae | *Pleurotus djamor*

Figure 1. Basidiocarps of different oyster mushroom species.

Substrate Preparation and Mushroom Cultivation

1. Selection and Preparation of Growing Substrates

The first step in oyster mushroom cultivation is the selection of appropriate substrates. These substrates are generally abundant and inexpensive, making them ideal for mushroom cultivation. The preparation of substrates typically involves chopping, soaking and pasteurizing to eliminate contaminants and enhance nutrient availability(Aditya *et al.*, 2022).

2. Spawn and Spawning

Spawn in oyster mushroom cultivation refers to the material that contains mycelium, the vegetative part of the fungus, used to inoculate the growing substrate and can be prepared on different types of grain substrates. Spawning is the process of introducing this spawn to the substrate, initiating the colonization that will eventually produce mushrooms. The rate of spawning usually varies from 2-5 percent (Aditya *et. al.*, 2024b).

3. Inoculation and Incubation

After substrate preparation, the next step is inoculation, where the substrate is mixed with mushroom spawn. This process can be done in various containers, such as plastic bags, bottles or trays.Following inoculation, the substrates are incubated in a controlled environment with optimal temperature, humidityand ventilation. The mycelium colonizes the substrate over several weeks, forming a dense network that will eventually produce mushrooms (Aditya *et. al.,* 2023).

4. Fruiting and Harvesting

Once the mycelium fully colonizes the substrate, the conditions are adjusted to initiate fruiting. This typically involves lowering the temperature, increasing humidity and providing light. Within a few days to weeks, the mushrooms begin to appear and can be harvested once they reach the desired size.Oyster mushrooms are typically harvested in multiple flushes over several weeks, providing a continuous supply of fresh mushrooms (Aditya *et. al.*, 2023; Aditya *et. al.*, 2024a). These harvested mushrooms are nutritionally rich and contain a number of bioactive compounds (Table 1). These mushrooms are rich in bioactive compounds such as polysaccharides, proteins and phenolic compounds, which exhibit antioxidant, anti-inflammatory, and immune-boosting properties, making them a valuable functional ingredient in health-promoting foods (Kour *et. al.*, 2022; Ritota, 2023).The spent substrate, now partially decomposed by the mushrooms, can be used as a nutrient-rich compost for soil amendment, completing the waste valorization cycle.

Table 1. Nutritional and Medicinal Importance of Oyster Mushrooms

Nutritional Importance of Oyster Mushrooms		
	Macronutrient	Uses
1.	Protein	Oyster mushrooms are an excellent source of high-quality protein, containing all essential amino acids. They typically provide about 15-35 percent of their dry weight as protein, making them a valuable protein source, especially for vegetarians and vegans.
2.	Carbohydrates	They are rich in dietary fiber, including both soluble and insoluble fiber, which aids in digestion and promotes gut health. The fiber content helps regulate blood sugar levels and lower cholesterol.
3.	Fats	Oyster mushrooms have a low-fat content, with the majority being unsaturated fatty acids, including linoleic acid. This makes them

		a heart-healthy food option.
Micronutrients		**Uses**
4.	Vitamins B complex	Oyster mushrooms are rich in B-complex vitamins, including B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), and B9 (folate). These vitamins play crucial roles in energy metabolism, brain function, and the production of red blood cells.
5.	Vitamin D	They contain ergosterol, a precursor to vitamin D2, which is converted into vitamin D2 when exposed to UV light. Vitamin D is essential for bone health and immune function.
6.	Vitamin C	Present in moderate amounts, contributing to immune health and antioxidant protection.
7.	Minerals	Oyster mushrooms provide significant amounts of minerals such as potassium, phosphorus, magnesium, iron, zinc and selenium. These minerals are vital for various physiological functions, including muscle and nerve function, bone health and antioxidant defence.
Medicinal Importance of Oyster Mushrooms		
Bioactive Compounds		**Uses**
8.	Flavonoids	These compounds have strong antioxidant properties, protecting cells from oxidative stress and reducing the risk of chronic diseases such as heart disease, diabetes and cancer. They help neutralize free radicals, thus preventing cellular damage.
9.	β-glucans	β-glucans are polysaccharides with potent immune-modulating properties. They enhance the body's immune response by activating macrophages, natural killer cells, and other components of the immune system.
10.	Phenolic compounds	Oyster mushrooms are rich in phenolic compounds, which have strong antioxidant and anti-inflammatory properties. These compounds can help reduce the risk of inflammatory diseases and oxidative stress-related conditions
11.	Polysaccharides	The polysaccharides in oyster mushrooms, particularly β-glucans have been shown to possess anti-tumour activity. They can inhibit the growth of cancer cells and stimulate the immune system to attack tumour cells.
12.	Fiber	The high fiber content in oyster mushrooms helps reduce cholesterol levels and improve heart health by promoting the excretion of bile acids.
13.	Lectins	Lectins from oyster mushrooms have shown potential anti-cancer properties by binding to cancer cell membranes and inducing apoptosis (programmed cell death).
14.	Sterols	Oyster mushrooms contain ergosterol, which can be converted into vitamin D2. Additionally, sterols in these mushrooms help lower cholesterol levels by inhibiting cholesterol absorption in the intestines.

15.	Terpenoids	These compounds possess strong anti-inflammatory properties, helping to reduce inflammation and associated symptoms in chronic conditions such as arthritis and inflammatory bowel disease.
16.	Antimicrobial compounds	Oyster mushrooms produce various antimicrobial compounds that can inhibit the growth of harmful bacteria, fungi and viruses, thereby supporting overall immune health.
17.	Ergothioneine	This is a unique antioxidant found in significant amounts in oyster mushrooms. Ergothioneine accumulates in tissues prone to oxidative stress and helps protect cells from damage.

Benefits of Waste Valorization through Mushroom Cultivation

1. Environmental benefits

A. Waste reduction: Utilizing agricultural and industrial wastes for mushroom cultivation significantly reduces the volume of waste destined for landfills and incineration.

B. Resource conservation: Converting waste into valuable products conserves natural resources by reducing the need for synthetic fertilizers and soil amendments.

C. Carbon sequestration: Oyster mushrooms contribute to carbon sequestration by decomposing organic matter and incorporating carbon into their biomass and the soil.

2. Economic benefits

A. Income generation: Mushroom cultivation provides a source of income for small-scale farmers, entrepreneurs and rural communities.

B. Cost savings: Using waste materials as substrates reduces the cost of mushroom production compared to conventional methods that rely on commercial substrates.

C. Value addition: The production of mushrooms from waste materials adds value to otherwise discarded resources, enhancing their economic potential.

3. Social benefits

A. Food security: Oyster mushrooms are a nutritious food source that can help improve dietary diversity and combat malnutrition.

B. Employment opportunities: Mushroom cultivation creates jobs in rural and urban areas, contributing to economic development and poverty alleviation.

C. Community engagement: The process of waste valorization through mushroom cultivation can foster community involvement and awareness of sustainable practices.

Challenges and Solutions

1. Technical challenges

A. Substrate contamination: Contamination by unwanted microorganisms can hinder mushroom growth. Solutions include proper pasteurization, maintaining hygienic conditions and using quality spawn.

B. Climate control: Maintaining optimal environmental conditions for mushroom growth can be challenging, especially in regions with extreme climates. The use of simple, low-cost climate control systems can mitigate this issue.

2. Economic challenges

A. Initial investment: The cost of setting up mushroom cultivation facilities can be a barrier for small-scale farmers. Providing microloans and subsidies can help overcome this hurdle.

B. Market access: Farmers may face difficulties accessing markets for their mushrooms. Establishing cooperatives and linking farmers with buyers can improve market access and ensure fair prices.

3. Social challenges

A. Awareness and training: Lack of knowledge and skills in mushroom cultivation can limit adoption. Conducting training programs and extension services can address this gap.

B. Cultural acceptance: In some regions, mushrooms may not be traditionally consumed. Promoting the nutritional and culinary benefits of mushrooms can enhance their acceptance.

Future Prospects

The potential for waste valorization through oyster mushroom cultivation is vast. As awareness of sustainable practices grows, more communities and industries are likely to adopt this approach. Future research and innovation can further optimize substrate utilization, improve yield and enhance the nutritional and medicinal properties of mushrooms. Advances in biotechnology and agricultural sciences can enhance substrate utilization, ensuring that mushrooms can grow more efficiently on a wider range of waste materials. Improvements in cultivation techniques can lead to higher yields, making mushroom farming more economically viable and accessible. Moreover, future research should also aim to boost the nutritional and medicinal properties of oyster mushrooms, potentially increasing their value as a health food. Enhanced mushroom cultivation can play a significant role in reducing waste, mitigating environmental impact and supporting public health. The synergy of waste valorization and mushroom farming exemplifies a circular economy approach, promising a more sustainable and resilient future.

Technological Innovations

A. Advanced substrate formulations: Developing new substrate formulations that maximize nutrient availability and mushroom yield.

B. Automation and monitoring: Implementing automated systems for climate control, substrate preparation and harvesting to increase efficiency and reduce labour costs.

C. Genetic improvement: Breeding and selecting oyster mushroom strains with enhanced growth rates, disease resistance and nutritional profiles.

Conclusion

Waste valorization through oyster mushroom cultivation presents a sustainable and multifaceted solution to the global waste management crisis. Transfor-ming agricultural and industrial wastes into valuable food products, this approach offers significant environmental, economic and social benefits. While challenges exist, targeted solutions and collaborative efforts can unlock the full potential of this innovative practice. As we move towards a more sustainable future, the integration of waste valorization and mushroom cultivation stands as a testament to the power of nature-based solutions in addressing complex global issues. Oyster mushrooms are a remarkable resource for their nutritional, bioactive and medicinal properties, as well as their contribution to sustainability. Rich in proteins, vitamins, minerals and fibers, they offer significant health benefits, including enhanced immune function, reduced inflammation, improved cardiovascular health and potential anti-cancer effects. Medicinally, they contain β-glucans and polysaccharides that boost the immune system, while ergothioneine and phenolic compounds provide strong antioxidant and anti-inflammatory benefits, aiding in the prevention of chronic and neurodegenerative diseases. Environmentally, their cultivation utilizes agricultural and industrial wastes, reducing landfill use, conserving resources and promoting sustainable farming through spent mushroom substrate as a soil amendment. Economically, oyster mushroom farming provides additional income and supports food security, particularly in resource-limited settings. Integrating their cultivation into waste management practices offers a holistic solution for health, sustainability, and economic development, aligning with global sustainability goals and fostering a healthier future.

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Hill Farming: Problem and Prospects

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Introduction

Hill farming, often romanticized for its picturesque landscapes and bucolic charm, embodies a way of life deeply intertwined with nature's rugged beauty (Clarke and Clarke, 2015). Yet, beneath the surface lies a complex web of challenges and opportunities unique to these elevated terrains. As the world we live in is progressing on a daily basis with the advent of new technologies and new innovations, the age-old practices that have been in practice in the hills from time immemorial need to change, as does the perception of people residing in hilly areas who still look into the traditional aspects of farming.We explore the many problems that hill farmers encounter as well as the bright future that lies ahead.

Challenges

1. Topographical Constraints including soil erosion

Hill farming is inherently constrained by the rugged topography of mountainous regions. Sloping terrains pose significant challenges for cultivation, making mechanization difficult and increasing erosion risks (Rao *et. al.*, 2016). Soil erosion is a menace that people residing in the hills need to encounter frequently and it can be managed by discouraging deforestation and also encouraging people to go for plantation drives.

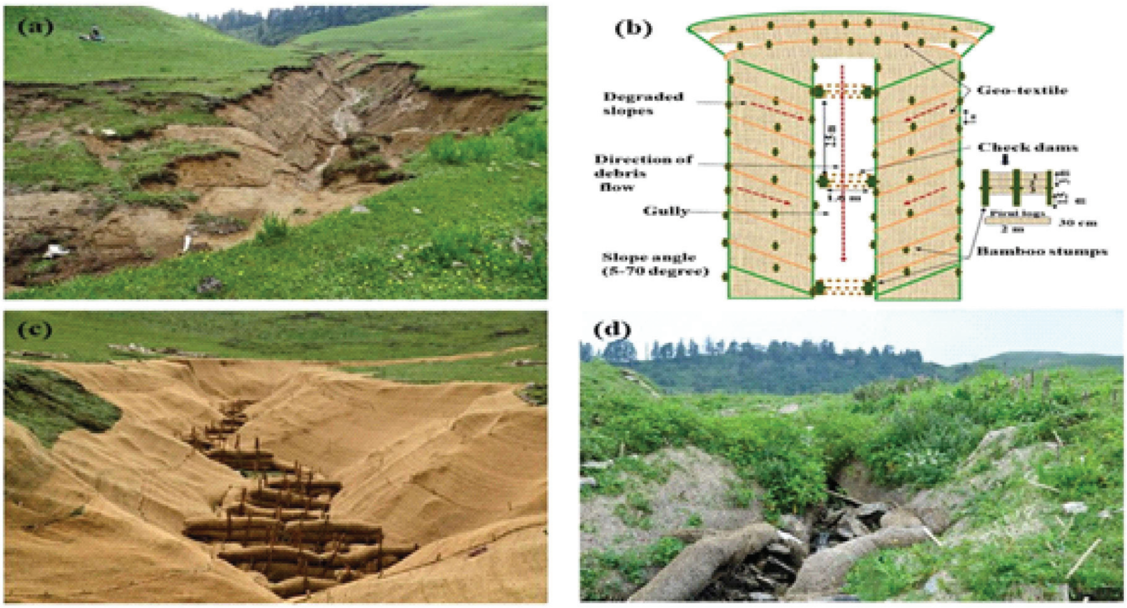

Fig. 1. Soil erosion control techniques (Jagdish *et. al.*, 2021)

2. Limited Arable Land

Unlike the vast expanses of flatlands, hill farming often operates on a limited arable area. This scarcity of cultivable land restricts the scale of operations and limits the types of crops that can be grown (Ker *et. al*., 2000).

3. Climate Variability

Hill regions are particularly susceptible to climate variability and extreme weather events. Erratic rainfall patterns, prolonged droughts, or sudden floods can devastate crops, leading to substantial losses for farmers (Crane *et. al*., 2011).In hill farming, as the climate changes, so does the environment for crops. This means pests and diseases also shift. Some pests, like those that suck plant juices, may become more common, while diseases like wheat yellow rust and rice blast could spread more easily. Yet, some pests might decrease in number. Farmers need to stay watchful and adaptable, finding ways to keep their crops healthy despite these changes. (Bhatt, *et. al*., 2015;) By paying close attention and making smart choices, they work to ensure their harvests remain strong in the face of nature's fluctuations.

4. Infrastructure and Accessibility

Remote hillside locations often suffer from inadequate infrastructure and poor accessibility. Limited road networks, unreliable transportation, and lack of essential services impede the efficient movement of goods and resources, exacerbating the challenges faced by farmers (Haokip and Reimeingam, 2021). Steep slopes, irregular fields and rocky patches make it challenging to use large-scale farm machinery. Farmers often have to rely on manual labor or smaller, specialized equipment, increas-ing production costs. Moving agricultural inputs, produce, and livestock to and from markets can be difficult and expensive due to narrow, winding roads and limited transportation options in remote areas.

5. Labour Shortages

Hill farming communities frequently grapple with labor shortages, as younger generations migrate to urban areas in search of alternative livelihoods (Pratap, 2011). The aging population further compounds this issue, posing a threat to the continuity of traditional farming practices.

Prospects

1. Biodiversity Conservation

Hill farming areas are often repositories of rich biodiversity, harboring diverse flora and fauna. Adopting sustainable farming practices can contribute to the preservation of these ecosystems, promoting biodiversity conservation and ecological resilience (Pal and Dasgupta, 2014).

2. Specialized Crop Cultivation

While arable land may be limited, hill farmers can capitalize on niche markets by cultivating specialized crops suited to the local climate and terrain. High-value crops such as herbs, medicinal plants, or organic produce can fetch premium prices, providing economic opportunities for farmers (Barah, 2010).

3. Agro-Tourism and Rural Development

The scenic beauty and cultural heritage of hill farming landscapes present opportunities for agro-tourism and rural development. By leveraging their unique selling points, hill farming communities can attract tourists, generate additional income streams, and foster local entrepreneurship (Singh *et. al*., 2017).

Fig. 3: Agro-tourism

(Source: aesanetwork.org)

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Agro-tourism holds tremendous scope in the coming days as people are getting more engaged in gaining some extra incentives and ultimately garners extra returns from their land and property.

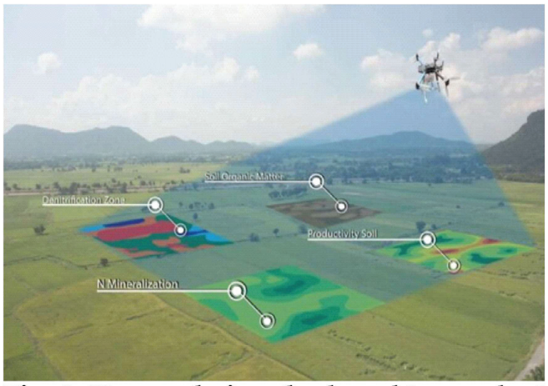

Fig. 2: Drones being deployed to conduct various agricultural activities (Source; Roboticsbiz)

4. Technology Adoption

Advancements in agricultural technology, such as precision farming techniques, vertical farming, and drone-based monitoring, unmanned agricultural vehicles (UAV's), hold promise for enhancing productivity and sustainability in hill farming (Despommier and Ellingson, 2008; Martos, *et. al.*, 2021; Padhiary *et. al.*, 2024). Innovative solutions tailored to the specific. Challenges of mountainous terrain can empower farmers to overcome traditional constraints.

5. Unique Products and Market Potential

Hilly areas can support the cultivation of a variety of niche crops that thrive in cooler climates and distinct soil conditions (Verma, ***et. al.***, 2015). These include fruits like berries, stone fruits, and apples, vegetables like baby greens and herbs, and specialty crops like saffron or lavender. These unique products often fetch premium prices in urban markets due to their freshness, flavor profile, and association with sustainable, local farming practices.

Conclusion

Hill farming has its ups and downs. The beautiful scenery might catch your eye, but dealing with the rough land and not much space for crops can be tough. Still, there's hope for the future. If farmers use smart ways of farming that take care of the environment, like stopping soil erosion and planting different crops, it can help a lot. Also, using new technology, such as precise farming and drones, can make farming easier and better. By mixing old and new ways, hill farmers can handle these challenges and make things better for the future. It's like a balancing act between nature and people. With new ideas, caring for the land, and working together, hill farmers can create a good future where nature and farming go hand in hand. They're like the guardians of the land, showing how to keep going even when things get tough.

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Artificial Intelligence in Agriculture: An Emerging Era of Research

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Introduction

The global population is anticipated to surpass nine billion by the middle of the century, necessitating a 70% increase in agricultural output to satisfy burgeoning demand. A mere 10% of this amplified production is expected to stem from the utilization of dormant lands, with the remaining 90% to be achieved through the intensification of existing agricultural practices. Hence, employing cutting-edge technological innovations is imperative to optimize farming efficiency.

Contemporary methods to enhance farm yields involve substantial energy consumption, while the market insists on high-quality provisions. The rising costs of labor, the escalating expenses associated with cultivation, crop losses attributed to erratic yields resulting from diseases, irregular rainfall, climate anomalies, soil fertility decline, and the volatile pricing of agricultural commodities, have all adversely impacted the financial and social standing of this fundamental demographic. Conversely, population growth has intensified the demand for food grains, leading to inflation in the cost of agricultural goods. Artificial intelligence paves the way for intelligent farming methods, minimizing the losses of cultivators and ensuring bountiful harvests. Through AI platforms, an extensive array of data sourced from government and public domains, alongside real-time surveillance utilizing IoT, can be analyzed with precision, enabling farmers to tackle the myriad uncertainties in agriculture.

By 2050, the UN forecasts that two-thirds of the global populace will inhabit urban regions, diminishing the rural labor force. Advanced technologies will thus be vital to alleviate the burden on farmers: tasks will be conducted remotely, processes automated, risks identified, and solutions implemented promptly. Future farmers will likely boast a skill set blending technological prowess with biological savvy, as opposed to traditional agricultural expertise.

The Role of Artificial Intelligence in Agricultural Practices

Artificial Intelligence can introduce a groundbreaking shift in the agricultural sector. AI-driven initiatives not only aid farmers in achieving more with fewer resources but also boost the quality of crops and expedite their journey to market. The progression of technology in Artificial Intelligence, Big Data, and IoT are now central in delivering digital IT solutions across industries. The proposal is to harness such digital solutions, augmented with Artificial Intelligence, to improve the lot of the downtrodden farming community while simultaneously carving new avenues for business and entrepreneurial ventures by instituting smart farm services.

1. *Evolution Powered by IoT*: The advent of digital technology is transforming agriculture. IoT enables the convergence of various forms of data, furnishing valuable insights for food production. Daily, copious volumes of data pertaining to historical climate patterns, soil analyses, recent scientific developments, precipitation, pest outbreaks, images from drones, and so on, are compiled. Cognitive IoT solutions can process this data to enhance crop yields. Technologies like Proximity Sensing and Remote Sensing are at the forefront of intelligent data amalgamation. A practical application of this detailed data is Soil Assessment. This involves the deployment of sensors either in airborne or satellite systems for remote sensing, or directly in contact with the soil for proximity sensing, facilitating soil characterization beneath the surface in specific locales. Hardware solutions, for instance, those engineered for corn cultivation, combine data-collection software with robotic technology to devise optimal fertilizers, enhancing yields. IoT sensors must be stationed in the fields at predetermined spots to gather vital growth indicators such as climate, soil moisture, nutrient levels, growth dynamics, and maturation stage of the crops.

The IoT apparatus encompasses transducers that evaluate environmental and crop parameters. It may include a mini board with WiFi connectivity, a controller, a cost-effective VGA image sensor, and solar power support. Data collection occurs at set intervals via WiFi hotspots strategically positioned for fieldwide coverage or through drones equipped with hotspot capabilities that also capture aerial footage of the field.

2. Data-Led Cultivation: By correlating weather, seed varieties, soil quality, disease probabilities, historic events, market dynamics, and prices, farmers can make well-informed choices for their crops.

3. Image-Derived Analytics: Precision agriculture leverages drone-captured imagery for exhaustive field examination, crop surveillance, and more. Combining computer vision, IoT, and drone data fosters prompt action from farmers. For instance, Aerialtronics integrates IBM Watson IoT and Visual Recognition APIs in drones to analyze images in real-time.

(i) Disease detection employs image processing to segment leaf images into areas such as the background, healthy, and affected parts. The afflicted sections are then scrutinized further in labs.

(ii) Crop maturation identification entails capturing images under specific lighting conditions to discern ripeness levels.

(iii) Field management involves using high-definition airborne imagery to map cultivation areas and determine crop water, nutrient, or pesticide needs, streamlining resource utilization.

4. Identifying Optimal Agronomic Mixes: Cognitive solutions provide crop and hybrid seed recommendations considering various factors like soil and weather conditions. Personalization further tailors advice considering local environmental factors and historical farming successes.

5. Crop Health Monitoring: Remote sensing, coupled with spectral imaging and 3D scanning, is imperative for establishing extensive crop metrics. This efficient monitoring method spans the entire crop lifecycle, including anomaly reporting.

6. Irrigation Automation and Farmer Aid: Automating irrigation, influenced by historical climate and soil data, can enhance yield ratios. With agriculture consuming 70% of freshwater, automation offers better water management.

7. Drone Innovations: Drones are revolutionizing agriculture, from soil and field analyses, seed distribution, crop spraying, monitoring, to irrigation and health assessments, becoming increasingly integral through the crop cycle.

Models for Farmer Services: Services for farmers could include chatbots, agri-e-calculators for crop selection, crop care, market guidance, and support with loans and insurance.

1. Chatbots: AI-driven virtual assistants, currently aiding various sectors, can offer farmers valuable advice and information in their native languages.

2. Agri-E-Calculator: This smart tool aids farmers in choosing crops and estimating resources based on diverse dependencies.

3. Crop Care Service: This service spans from sowing to harvest, analyzing complex data obtained from IoT sensors, other information sources, and expert input, employing AI techniques to provide actionable insights.

4. Price Prediction and Market Guidance: Protecting farmers from market volatility, this service offers predictive pricing and demand information through statistical data analysis, aiding farmers in strategic market release planning for their produce.

5. Crop Loan and Insurance Service: Facilitating farmers with feasibility access to crop loans and insurance, this service provides smart estimations and eligibility criteria for crop cultivation, securing farmer investments against uncertainties.

Current Implementations of AI in Agriculture

- **Blue River Technology:** Focused on lessening chemical use and cost savings, it employs artificial intelligence, computer vision, and robotics to identify and treat each individual plant.
- **FarmBot:** Offers precision farming technology for individual use, managing everything from seed planting to plant watering with open-source software.
- **Harvest CROO Robotics:** Introduces robotics in strawberry picking, aiming to overcome labor shortages and enhance productivity and quality.
- **Plantix:** A smartphone app that diagnoses plant health and soil deficiencies, employing AI and machine learning for disease solutions.
- **Prospera:** Provides cloud-based solutions that aggregate diverse farming data, such as soil/water sensors and aerial images, to make informed decisions.

Challenges in AI-Driven Agriculture

Despite the potential, integrating AI in agriculture faces challenges like familiarization with high-tech solutions and the dynamic nature of factors such as weather, pests, and soil conditions, which may render an optimal solution ineffective over time. The technology requires significant data to train algorithms and may take time to develop robust models, hindering AI's application to in-field precision solutions.

Conclusion

AI solutions empower farmers to analyze various factors like land, soil, and crop health, saving time and facilitating the choice of optimal crops each season. Moving towards vertical farming can economize water and land usage, reduce labor issues, and allow for urban cultivation. AI technology enables the prediction of crop seasons, weather changes, and appropriate interventions, averting widespread diseases. With vast potential for introducing automatic response systems in agriculture, emerging technology like chatbots can assist farmers with answers and recommendations, stimulating the AI market's growth in the agricultural industry.

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Impacts of Canopy on Pest and Disease Development in Fruit Trees

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Introduction

In fruit production systems, tree canopy structures are manipulated to optimize radiation interception by leaves which enhance their physiological activity and results in higher yield. Relationships between the canopy structure and the tree physiology have been widely investigated and modeled, but much more less attention has been paid to effects on pest and diseases development, especially in fruit trees. Plant canopies are highly structured environments set by the size, shape, orientation and density of plant organs. Such complex structures can act at least at two levels. First, pathogens and insect herbivores, predators and hymenopterous parasitoids are not evenly distributed within plant canopies and their movements depend on the level of connectedness between plant organs. Second, architecture directly sets the heterogeneity of microclimatic conditions which in turn influences the performance of pests (Pincebourde *et al*. 2007). Manipulating plant canopy architecture is likely to influence these aspects of insect ecology The architecture of crop plants is influenced by endogenous factors (hormone signals, trophic competition between organs) as well as by exogenous factors (light distribution, soil water, nutrients of organs, temperature, wind). For perennial plants, the crop density and the pruning type are defined at planting time, while significant changes in growth and architecture can be generated during the vegetative season by cultural practices. Some of these practices act on exogenous factors which have a positive effect on primary growth and ramification.

Plant architecture and its interactions with pest and pathogen

Crop structure, planting density, pruning and training system can generate various spatial canopy structures or the spatial distribution of organs at plant level, with consequences for epidemics. In grapevine, the row structure of the crop was suspected to have an effect on the dispersal of the wind-dispersed, xerophilic spores of powdery mildew (Erysiphenecator). The velocity of disease spread decreased along the row with an enhanced effect in highly vigorous plots (with a high visual density of leaves), whereas vigour was conducive to disease spread between rows (Calonnec *et al.* 2009). In apple orchards, the development of apple scab, caused by Venturia inaequalis, depended on the training system (Simon *et al.* 2006). The effect of the training system might be caused either by inoculum removal during the thinning cut of fruiting spurs, or by a decrease in leaf wetness duration due to increased light penetration. On grapevine, free positioned top vines experienced a higher level of powdery mildew on bunches than on vertical shoot positioned vines (Zahavi *et al*. 2001). Similarly, vines with the highest level of disease on clusters were those that have a significantly lower proportion of clusters well exposed to sunlight (Austin and Wilcox 2011). Additionally, clusters that were well exposed to sunlight were also well exposed to spray deposit. Thus, canopy management practices designed to optimize the sunlight exposure of grape clusters for fruit quality purpose should also significantly contribute to the management of the disease. In fact, different types of management (e.g., cover-crop, weed control, irrigation, and fertilization) showed significant positive correlations between the disease incidence and shoot vigour (Valdes-Gomez *et al*. 2008). Light could have indirectly decreased pathogen infection on berries through modifications of plant physiology, such as a decrease in pH and K concentration and an increase in polyphenol and anthocyanin concentration (Zahavi and Reuveni 2012). Indeed, berries picked in the field from two vine training systems were inoculated and incubated in controlled conditions and those that had been collected under the system which received 50% less radiation intensity had higher disease incidence. Manipulating plant canopy architecture is likely to influence aspects of insect ecology and disease epidemiology. Indeed, the hypothesis that there should be canopy configurations minimizing pathogen and insect herbivore population development has been evoked (Simon *et al.* 2006, 2007); however it has never been tested properly. Using conceptual and methodological advances of model-assisted design of ideotypes, the complex interactions between architectural traits and several pest ecological and epidemiological processes can be studied which will facilitate in exploiting full advantage of the rapid advances in high-throughput (Andrivon *et al.*, 2013). This will pave the way to envisage about designing plant canopy ideotypes within cropping system ideotypes, as one component of the cropping system, rather than as the product of this system.

Conclusion

Research on canopy architecture in fruit trees, has focussed mainly on improving and/or regulating fruit yield and fruit quality. Though the relationships between tree structure and pest infestations or pathogen infections have long been recognized, but such inter-relations are seldom established on a scientific basis. Among the plant traits, the influence of tree architecture on herbivorous insects and diseases is probably the least studied. While architecture has a strong genetic component, it can also be manipulated through different horticultural approaches. The architecture of plant canopies interacts with environmental factors to create a diverse range of microclimates. Plant canopy architecture and microclimate can be affected by both training system and cultivar. Pruning fruit trees exert a negative impact on build-up of pests and disease by altering microclimate and architecture of the canopy particularly better aeration, decreased shoot and canopy density thereby improving pesticide penetration and deposition. The main reason for this is that an unpruned tree provides more shaded leaves within the tree crown owing to higher foliage density. Besides, modification in tree architectural features altered changes in tree physiology inducing resistance or otherwise changing tissue susceptibility which inturn generates favourable or unfavourable conditions for development of host populations.

Management of plant architecture could

provide an innovative alternative for low pesticide pest management systems and provide an eco-friendly approach to control pest development under the expected changing climate. Hence, in addition to genetic resistance, the use of a plant architecture which produces a less favourable microenvironment for fungal infection could significantly reduce disease.

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Land Reforms in India: An Overview

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Introduction

In India, 35% of the operational area in farming is owned by small and marginal farmers. However, these holdings are scattered and unconsolidated hence economically nonviable for higher investment and collective approaches in farming, e.g., mechanization, irrigation investment etc. farm inputs. Here lies the importance of proper land reforms and their implementation to augment production and yield by consolidating the land masses. There has also been a growing realization among small and medium farmers that, with the development of market forces and rising (fixed and variable) costs, the present mode of production wouldn't stably stay forever. It is imperative now to enact policies to encourage investment in agriculture and allied sectors by land consolidation to enhance productivity, better quality and encourage investment by alleviating the perils and sensational issues. In regards to the tunings of the agrarian society of India, Government of India advocated individual peasant farming, under Cooperative joint farming. In 1955, West Bengal government enacted the Land Reforms Act to consider the right of bargadars for hereditary cultivation and raising the shares up to 75% of the gross produces if he supplies all the inputs or 50% if he supplies all the inputs except labor (supplied by the landowner). With the help of commercial and cooperative banks institutional credits were provided to sharecroppers and beneficiaries of ceiling surplus landholders. The operation laid to the documentation and recording of nearly 50 lakh sharecroppers covering 11 lakh acres of land. Land Reforms Act were legalized with three broad variations- Abolishment of intermediate, Regulation of landholding size through ceiling imposition and redistribution, Tenancy settlement and regulation.

Historical Background

The need for radical changes in the land tenancy system was first realized by peasant leaders of Congress in the 1930s and 1940s. With a rising sense of nationalism and strong understanding on what the farmers (i.e., the real India) are thinking and facing, they could authentically sense the requirements and difficulties faced by them. They not only hold a key position in NationalCongress in a political dimension but also had a good comprehension of the agricultural system of the country and peasant cum farming community. In 1945 National Planning Committee passed a resolution on land reforms. In 1949, a comprehensive report was submitted by Agrarian Reform Committee, covering demands on major issues like-

- No scope of exploitation or interclass dominance
- Schemes and ideas of reforms should be within the ambit of practicability
- Abolishment of all intermediates
- Those who put in a minimum amount of physical labor and participate in actual agriculture operations should be deemed to cultivate

• Land holding based on holding size

On the size of holding the committee evolved the concept of three types of holding

• Economic holding
• Basic holding
• Optimum holding

In regards to the tunings of the agrarian society of India, the committee advocated individual peasant farming to constitute a general pattern of socioeconomic structure of Indian agrarian society. Small Holders were attempted to bring them under Cooperative joint farming (individual ownership & collective operation), collective farming was also considered to beapt and just for the development of reclaimed waste on which landless laborers could be settled.

However, practical experiences have shown that joint farming, even in respect of farmers with uneconomic holdings, may not be proper to the frame or temperament of the ecosystem of Indian cultivation. The solution seems to give an additional capital base to such farmers as advocated in the integrated Rural development concept also. It also became a good fit model concerning landless agriculture laborers.

Progress of Land Reforms

In early times village panchayats were asked to play a vital role in correcting the land records. In the 2nd 5-Years' Plan, the land reforms were found to provide a social, economic and institutional foundation for agricultural development with a coast-to-coast synchrony. In the 4th and 5th 5-Years' Plans, plans and formulated policies were evaluated along with the land reform protocols and they were acknowledged between objectives and legislation, law and implementation. The study suggested that 16% of tenants were conferred ownerships and tenants and sharecroppers with insecure tenurewere estimated to be 82% of the total number. States like Andhra Pradesh, Karnataka, Himachal Pradesh, Madhya Pradesh and Uttar Pradesh prohibited (with strict law) leasing out of agricultural land except for certain disabled categories like widows, minors, armed personnel etc. Punjab, Haryana, Gujarat and Maharashtra didn't ban leasing butthe tenant acquires the right to purchase the leased land from the owner within a specific period aftercreation of tenancy. West Bengal, Andhra Pradesh and Odisha put no restriction on land leasing although in West Bengal only share cropping leases are allowed.

Operation Barga

Operation Barga (1978) is a major example in terms of Land Resource Management and the context of Land Reforms and is still considered a political success of the newly established Left Front Government (elected in 1977) in agrarian dominating West Bengal. In 1955, the then West Bengal government enacted the Land Reforms Act to consider the right of bargadars for hereditary cultivation and raising the shares up to 75% of the gross produces if he supplies all the inputs or 50% if he supplies all the inputs except labor (supplied by the landowner). With the help of commercial and cooperative banks institutional credits were provided to sharecroppers and beneficiaries of ceiling surplus landholders. The operation laid to the documentation and recording of nearly 50 lakh sharecroppers covering 11 lakh acres of land.

As per the Article 39 of the Indian Constitution (under 'Directive Principles of State Policies') the Constitution has directed states to implement policies to ensure that all citizens have the right to adequate means of livelihood and that all community resources be distributed to serve the common goal. Land Reforms are always carried out under this directive. The constitution has been amended 13 times so far to remove legal obstacles to land reforms and give a constitutional backing and legal framework. Even for every 5-Year Plan it emphasizes the need for Land Reforms and expands policy guidelines to ensuresuitable land reforms. Land, being a state subject, state governments were directed to introduce the Agriculture Land Ceiling Act limiting the size of land holding and redistributing excess land among landless and marginal farmers. West Bengal was the first state to impose a ceiling on agriculture and land holdings by enacting the Land Reforms Act in 1955. In 1974-75 the ceiling limits were further brought down for tackling the then acute food crisis.

Near about 300 laws have been reformed and composed so far to enhance the concerning ambit and implement it.

Types of Land Reforms Act

The Land Reforms Act can be categorized into following types –

Abolishment of intermediate	The first initiative to overturn intermediaries started in 1972 by Uttar Pradesh Government. The aim was not to have any intermediate between the state and cultivator or payment of compensation to the owner. It ultimately resulted in 20 million cultivators being the owners of the land and 58 lakhs ha. to be redistributed. However, this proposition failed to reorganize significant changes in the society in terms of reducing inequalities in landholding or improving the plight of subtenants, sharecroppers and agricultural laborers without any occupancy rights. Large and powerful zamindars were well compensated for their land.
Regulation of landholding size through ceiling imposition and redistribution	To check the monopoly of large farmers in landholding in Uttar Pradesh and West Bengal, ceilings were made 40 acres and 25 acres for existing holding and 121 acres and 125 acres for future acquisitions respectively. It varies state-wise, based onfamily or individual land holdings. Large landholders took advantage of the loopholes in the law and the lack of an efficient land record system to underreport holdings and transfer land to fictitious and 'benami' holders. Some states have achieved better results from these reforms, notably West Bengal, Jammu and Kashmir and Assam. It also had a better impact on states like Uttar Pradesh where agroecological conditions are conducive and the government has given a helping hand.
Tenancy settlement and regulation	In the 1st 5-years plan, guidelines were authoredfor the tenants who couldn't exceed 20 to 25% of the total produce. All the states enacted laws broadly on these lines with slight interstate variation. State governments passed laws aiming at the prevention of unlawful eviction of tenants, allowing the resumption of land by the owner only for personal cultivation. The tenants were given ownership rights with legal enforcement and authorized backing with proper records and documents. However, many tenants could not get ownership rights because they were unable to fill large amounts of compensation. This plan was not successful in all states but in West Bengal, Maharashtra and Tamil Nadu it was successful.

Consolidation of Land Holding

In major parts of the country, land holdings are small and fragmented. Neither improved farm practices nor proper agronomic measures can be implemented inthe fragmented land. On the other hand, in the states like Punjab, Haryana, and Western Uttar Pradesh land consolidation helped farmers to get Canal irrigation, installment of individual tubewell, pump set, mechanized operation, high-yielding variety (HYV) introduction and adoption of improved practices. Land consolidation served as a prerequisite for modernization. So, land consolidation was a obligation for agricultural growth and development along with economic progress.

Conclusion

Land reforms in India has always been a debated and popularly discussed topic in the context of Agricultural Economics, Public policy and also in its political ambit due to several controversies. Operation Barga (and India's land reforms in general) have been criticized for their smallerambit and inability to solve all the existing drawbacks. This criticism has been mainly for policies not accounting for the high population-to-landmass ratio in Bengal (the highest in the country), small and heavily segregated land patterns and administrative failure to develop agro-basedsecondary sectors for farm produce. These have been derogated to distribute poverty rather than creating prosperity. It has also been pointed out that despite these measures, Bengal's agricultural infrastructure and financial condition or employment situationare no better in comparative senses. Recent reports have indicated that the success of Operation Barga has not continued after its termination: hence it was temporary and not highly impactful.

National Sample Survey Office (NSSO), under Ministry of Statistics & Project Implementation, has reported in 1999 that only 31% of all sharecroppers were registered, with a strong class bias. Such a class bias along with the involvement of creamy agricultural class, has led to a creation of the "rural rich", while the poorer and backward groups havebeen comparatively marginalized. NSSO data also noted that the landlords continued to own the largest holdings in the villages which is substantially increased. Unsatisfactory performance of these bargadars (even those who received their stipulated crop share) was because of their poor resource base, lack of access to modern technology and capital market with the ultimate incapacity to acquire material resources. The imperfections in input markets also improvised the performance of the bargadars. Several political parties and certain group of societies marked these land review policies as anti-landowner, considering some draconian measures that could be misused.

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Farming Application :Agri-Market App

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Introduction

The AgriMarket Application, launched to provide prompt and up-to-date information to farmers concerning crop prices and agricultural methodologies adopted at markets located within a 50-kilometer radius, stands as a pivotal tool in the hands of farmers nationwide.

Developed by the Ministry of Agriculture's IT department, this mobile application aims to equip farmers with essential insights into crop pricing dynamics. Accessible through both the Google Play Store and the mKisan government portal, AgriMarket offers farmers a comprehensive platform to access real-time crop prices, crop insurance details, and other pertinent agricultural information officially disseminated by the government.

Overview

App Name	AgriMarket App
App Source	Central Government
Target Audience	Farmers across the nation
Benefit	Immediate access to crop price information from nearby markets
Primary Objective	Provide timely and accurate information to farmers regarding crop prices and agricultural practices within a 50-kilometer radius of their location

Objectives and Advantages

1. AgriMarket app serves as an informational hub and digital interface for farmers.
2. It delivers digital updates on crop prices, crop insurance, and agricultural practices.
3. Designed to be user-friendly, ensuring accessibility for farmers.
4. Available for download via the Google Play Store, ensuring widespread accessibility.
5. Empowers farmers with essential information, enhancing decision-making.
6. Facilitates access to crop prices within a 50-kilometer radius of farmers' locations.
7. Enables farmers to secure fair prices for their produce, reducing middlemen influence.

Conclusion

1. The central government has introduced the AgriMarket app to facilitate farmers nationwide.
2. This app serves as a conduit for farmers to access crop price information from nearby markets.
3. Real-time updates are provided within a 50-kilometer radius of the farmer's location.
4. Utilizing GPS, the app suggests crop prices based on the farmer's location.

5. Alternatively, farmers can scan barcodes if they prefer not to use GPS or encounter technical issues.
6. The app supports both English and Hindi languages for wider accessibility.
7. Farmers can select their preferred language for ease of use.
8. This language option enhances farmers' comprehension of the application.
9. Designed with simplicity in mind, the app caters to farmers of all backgrounds.
10. Farmers gain immediate access to market prices, empowering them to set fair prices for their produce.
11. By bypassing middlemen, the app safeguards farmers from price exploitation.
12. Encouraging digital adoption, the app encourages farmers to embrace technology for information retrieval.
13. In addition to crop prices, the app provides insights into insurance and agricultural practices.
14. The app ensures a secure environment with pertinent information for farmers.
15. Available for free download on the Google Play Store and the mKisan portal's Mobile apps section.

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Lodging in Rice: A Serious Problem in Paddy Cultivation, It's Insights, Impacts and Prevention Strategies at Farmer's Field Level

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Fig. 1. Place-Haringhata, Nadia (Copyright protected)

Fig 2. Place-Tior, Hilli, Dakshin Dinajpur (Copyright protected)

Introduction

Rice is a major cereal crop which has been consumed worldwide since the ancient time contributing a significant portion in maintaining world food security (FAO, 2014). It sustains approx. 66.66% of the world's population as a staple food (Sen *et. al.*, 2020). Asia has been sharing the largest population strength among all continents and thus naturally food grain consumption scenario is also the highest here. China and India together exhibit more than the half of the world's rice consumption exhibits high consumption levels, especially in China and India, which together consume over 50% of the world's rice. Other hand, global population is increasing in like geometric progression, now turned into population blast. By 2024, India's population is estimated to be around 1.44 billion (FAO). It is predicted that the demand for rice will be increased from 496 million tonnes (Mt.) in 2020 to 553 Mt. by 2035, and 623 Mt. by 2050 (FAO, 2013; Timsina *et al.*, 2021). At this overshooting situation of food grain demand – supply dynamics, especially in case of rice production, a small reduction in global rice yield and production may causes severe food crisis. Lodging has become a more or less common phenomena in most of the paddy growing areas in India (Fig.1 & 2) causing a huge loss in terms of both produce and economy of a farmer.

Lodging in Rice

When the paddy stem is no longer capable to stand straight upright position and bent down over the land along with entire shoot portion, called Lodging. It is nothing but the permanent displacement of rice stem from its upright position anddrooping over the land surface which causes severe losses in grain yield.

Based on field level observation, there are generally two types of lodging occurring in rice plant, as described below (Pinthus, 1974):

a. Culm breaking and Basal internode lodging: It is the permanent displacement and bending down of paddy stem from their straight upright position. It is commonly called as Stem lodging which occurred when the stem deflection exceeds the elastic limit of the stem. It has been observed thatstem lodging may be occurred at three different sites in rice (Bhiah *et. al*., 2010), at the stem base portion, at the inter-nodal portion, and at the heavy panicles (Fig. 3 & 6).

b. Root lodging: It is nothing but the failure of soil anchorage strength with plant rootswhich depends on the diameter of the root-soil cone, coronal root bending strength and soil shearing strength (Fig. 3 & 6).

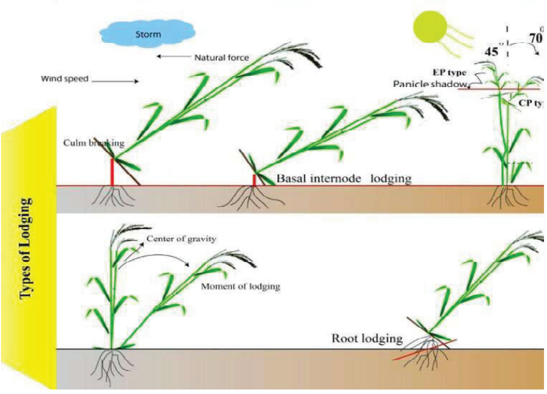

Fig 3. Stem lodging (Basal Internode lodging) and Root lodging (Shah *et al.*, 2017)

Reasons behind lodging incidence in rice

The main reason behind lodging is excessive vegetative growth as well as weakening of culm strength. Susceptibility or resistance mechanism of lodging in plants sometimes genetically inherited. Generally, when the weight of upper shoot portion of any rice plant increased by excessive vegetative growth, height as well as grain loads and the lower part of stem gets weakened by disease attack or less structural rigidity, the lower stem strength can't be able to bear the upper shoot load, causing lodging of plant. Imbalance usage of fertilizers leading to lodging phenomena in rice and negatively impacting on yield reported by Zaman et al., 2015. Higher doses of nitrogen fertilization promoteexcessive vegetative growth, increases the chance of lodging which decreases the yield (Basak *et al.*, 1962) (Fig.4).

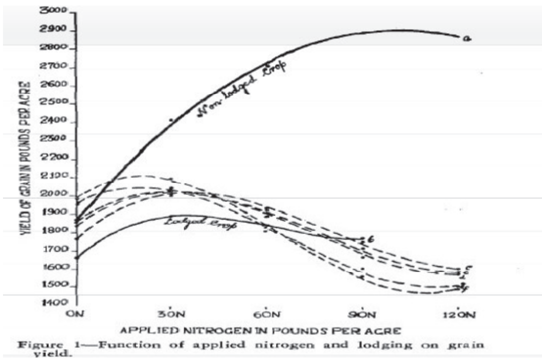

Fig.4. Lodging induced rice grain yield reduction due to excess nitrogen application (Basak *et al.*, 1962)

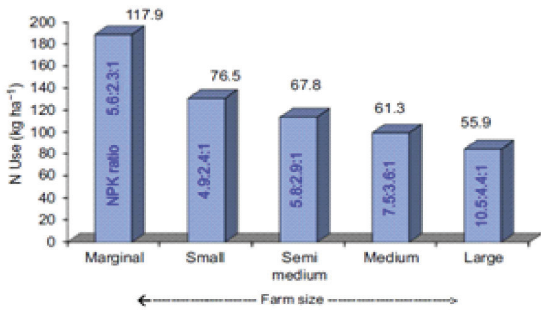

Fig.5. Land holding wiseN-P-K use ratio

Several external factors such like heavy rainfall, win current, hail, storm, excessive irrigation etc., act as an instrument in causing lodging incidence. Due to rainfall and excessive moisture condition in soil, the shearing cohesive binding strength of soil aggregatesaround plant roots almost get deteriorated. It loosens the root-soil anchorage system which may causes lodging.

Plant height, culm diameter, cell wall thickness, nature of vascular bundle tissues, cellulose contain in stem cells etc. togetherdetermines the susceptibility or resistance of any plants towards lodging. Due to excessive nitrogen fertilization, decreasingof the thickness of culm cell wall and culm diameter occurs which imparts poor lodging resistance in rice (Kashiwagi *et al*., 2008).

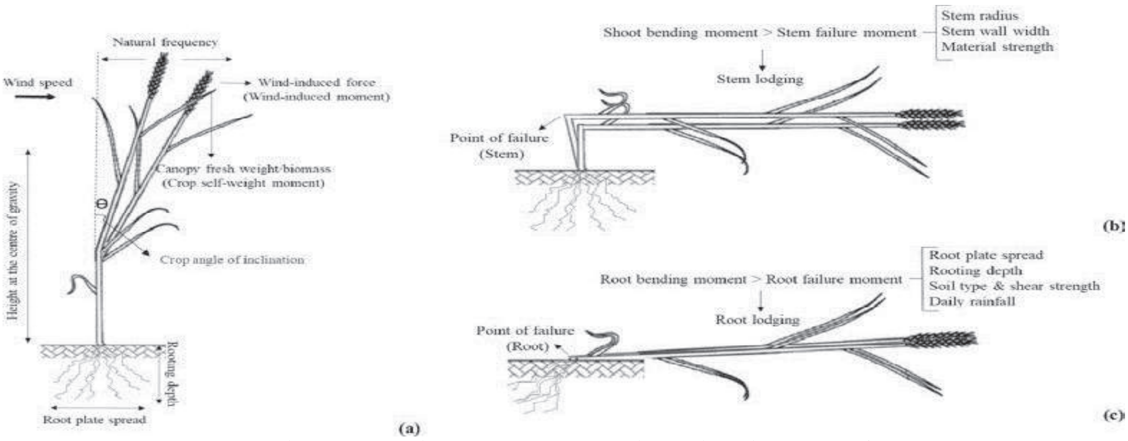

Fig.6. Lodging mechanism in cereals (Chauhan *et al*., 2019)

- **Lodging Index%** = (Bending Moment/ Breaking Resistance) x 100
- **Bending Moment**= (Total length of rice plants -Second internodes from above ground) x total fresh weight of whole rice plants including panicle

(Zhang *et al*., 2019)

Negative impacts of lodging

i. Lodging is a very undesirable phenomena in respect of both yield and famer's economy. It hampers harvesting operation and increases operational costs for farmers.

ii. 30-35% grain yield can be reduced due to lodging in rice.

iii. Moreover, grain quality also gets deteriorated due to lodging. Lodging often causes shrivelling of the grain and thus its testweight gets reduced.

iv. Lodging increases the chances of fungal contamination and disease attack.

v. Lodgingalso affects several metabolic activities of plant. It hampers the photosynthesis process, food translocation, water and nutrient uptake etc.

vi. Straw yield also gets reduced due to lodging, not only in rice but in the crops also, especially in cereals. Mulder in 1954 reported that the straw yield can be reduced up to 21% and 25% respectively in case of oat and wheat.

vii. Farmers face economic losses.

Management strategies

i. First of all, lodging resistant cultivar should be chosen having comparatively larger culm diameter, thicker cell wall, well-structured and more number of vascular bundles, presence of more amount of cellulose, lignin in stem cell wall etc.

ii. Sowing date of crop should be optimized. Sometimes too early or too late sowing causes lodging. So, sowing of any crop cultivar should be done at proper time.

iii. Time and frequency of irrigation should be maintained. Sometimes, late irrigation causes lodging.

iv. Avoid excess amount of nitrogen application. Nitrogen application should be completely avoided during the reproductive growth stage of rice. Nitrogen should always be applied into minimum three split doses (50% as Basal + 25% as two top dressing). So, application timing and dose of nitrogen fertilizer is very important at this perspective.

Year	Treatment	Plant K conc. (ppm)	Plant Si conc. (ppm)
2015	C_0	3.75^{e}	2.71^{c}
	CU	6.60^{d}	3.69^{b}
	CRU1	7.13^{b}	3.79^{b}
	CRU2	6.89^{c}	4.10^{ab}
	CRU3	**7.53^{a}**	**4.20^{a}**
	CRU4	6.66^{d}	**4.20^{a}**
2016	C_0	4.23^{d}	2.91^{e}
	CU	5.53^{c}	3.72^{c}
	CRU1	5.61^{c}	3.15^{d}
	CRU2	6.03^{bc}	3.85^{bc}
	CRU3	6.23^{b}	**4.12^{a}**
	CRU4	**6.51^{a}**	3.99^{b}

Year	Treatment	Bending Moment (BM)	Breaking Resistance (BR)	Lodging Index (BM/BRx100%)
2015	C_0	333.00^{e}	225.00^{d}	148.81^{b}
	CU	528.24^{c}	289.67^{c}	**182.60^{a}**
	CRU1	457.13^{d}	302.00^{c}	151.62^{b}
	CRU2	503.61^{cd}	364.67^{b}	138.85^{b}
	CRU3	607.70^{b}	396.33^{b}	153.37^{b}
	CRU4	683.43^{a}	443.67^{a}	154.32^{b}
2016	C_0	386.95^{d}	258.00^{e}	150.96^{c}
	CU	652.55^{b}	306.67^{d}	**212.94^{a}**
	CRU1	567.60^{c}	285.33^{de}	**199.24^{a}**
	CRU2	646.67^{b}	365.00^{c}	177.20^{b}
	CRU3	758.77^{a}	420.33^{b}	180.64^{b}
	CRU4	763.70^{a}	468.67^{a}	163.11^{bc}

Table.1 & 2. Effect of Conventional and Controlled release Urea on lodging Index and K, Si accumulation in rice (Zhang *et al.*, 2019)

v. 4R nutrient stewardship (right time, right source, right place and rite rate) should be followed during fertilizer application. Site specific soil test based fertilizer application strategy should be followed if possible.

vi. Optimum amount ofpotassic fertilizer should be applied in soil. Along with basal dose, at least one top dressing application of potassium should be carried out maintaining optimum rate or proportion.

vii. It has been scientifically proved through several on field experiments that optimum K fertilization leads to more K uptake in plant tissue which imparts mechanical strength in rice stem preventing lodging incidence (Zaman *et al.*, 2015).

viii. It is also observed that application of potassium promotes accumulation of silicon in rice stem which together strengthen rice stem against lodging and other environmentalstresses (Zaman *et al.*, 2015) (Fig.7).

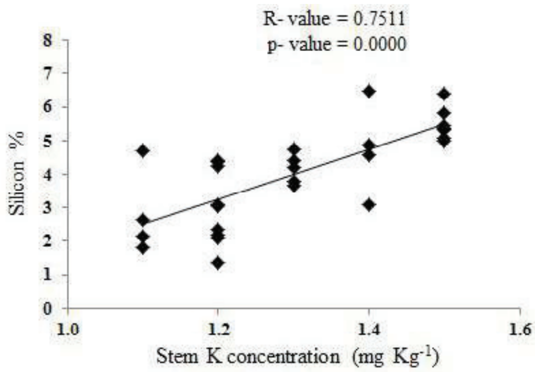

Fig.7. Correlation between Stem K conc. And stem Si % (Zaman *et al.*, 2015)

ix. Application of Silicon, a non-conventional practice, should be introduced at farmer's field level in case of rice cultivation. It was reported by several scientists that silica can impart structural rigidity in rice stems.

x.Silicon accumulation in rice stem tissues enhances cell wall thickness, size and number of vascular bundles, sclerenchyma and collenchyma tissues and decreases the fourth inter nodal length from above ground thus it enhances breaking resistance in rice stem and reduces lodging index (Kim *et al*., 2002; Salman *et al*., 2012).

xi. Use of controlled release fertilizer, especially controlled or slow release urea (neem coated or polymer coated) should be recommended to check the availability and uptake of nitrogen more than the requirement and excessive vegetative growth of rice plant. Zhang *et al*., 2019 reported that rice plants from the controlled release urea treated plot exhibit less tendency of lodging than those from the conventional urea treated plots (Table.2).

xii. Zhang *et al*., also reported that rice plants from the controlled released urea treated plots have a comparatively higher accumulation of potassium and silicon in their stem tissue than those from the conventional urea treated plots (Table.1).

xiii. It has also been reported by Hussain and Leitch, 2007 that application of sulphur often reduces the chances of lodging phenomena (Hussain and Leitch, 2007).

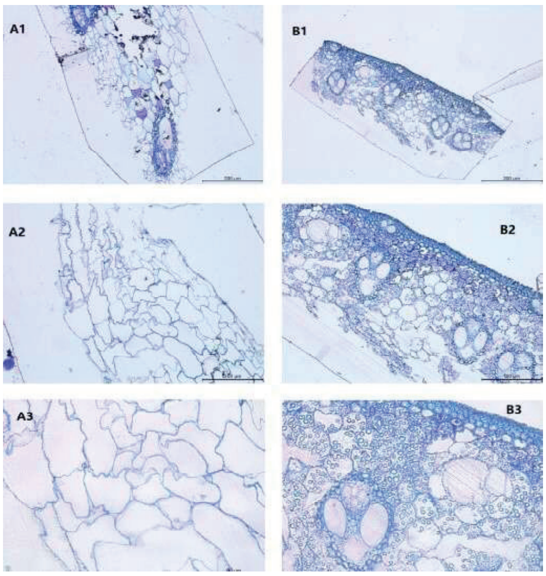

Fig.8. Images of rice stem cells from urea treatment A1–A3 & from controlled-release urea treatment B1–B3 respectively (Zhang *et al*., 2019)

Conclusion

By several studies and experiments we can conclude that Potassium and Silicon fertilization plays a vital role in resisting lodging phenomena in rice plants. Several lodging resistance rice varieties also have been developed through suitable breeding methods, it is okay but due to excessive vegetative growth and poor management practices, resistant varieties can also exhibit lodging phenomena. Dwarf rice varieties are also sometimes get weakened due to deficiency of potassium, silicon and other nutrients. Moreover, farmers all-time can't afford for lodging resisting varieties because choosing a particular variety also depends on land characteristics, geographic region, demand, price cost etc. So, optimum nutrient management strategy is only the way that can be afforded by every farmer even when resources are limited. Sufficient accumulation of potassium into plant tissue from soil solution activates several enzymatic systems which boosts up the synthesis of several body building proteins, complex carbohydrate polymers etc. It helps in lignin deposition in vascular bundle and sclerenchyma tissues in cell walls of stems which together imparts resistance against lodging. Silicon also helps in thickening (silicification+lignification) of stem cell walls, vascular bundles, vascular sheaths and improves sclerenchyma and collenchyma tissues, keratinocytes and enhance cellulose content leading to lodging resistance in rice. Balance application of nitrogen and potassium also enhances proper root growth and distribution which provides a better root-soil anchorage system leads to develop lodging resistance in rice. So, site specific soil test based fertilizer recommendation and application should be followed to bring optimality in nutrient management to prevent the lodging chance in rice.

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Exploring Biostimulants as a Sustainable Solution for Vegetable Growers

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Introduction

Vegetable farming faces increasing pressure to produce high yields while minimizing environmental impact. Biostimulants, a category of non-nutrient amendments, offer a promising solution for sustainable vegetable production. Vegetable farming is a cornerstone of global agriculture, providing essential nutrients to populations worldwide and playing a key role in food security and nutritional health. As the demand for fresh, sustainable produce increases, innovative farming practices that enhance crop yield and quality while minimizing environmental impact are becoming essential. One such innovation is the use of biostimulants, which are natural or synthetic substances that enhance plant growth and productivity through mechanisms distinct from traditional fertilizers and pesticides. The global demand for vegetables is steadily rising due to population growth and dietary shifts. However, conventional vegetable farming practices often rely heavily on chemical fertilizers and pesticides, leading to environmental concerns like soil degradation, water pollution, and greenhouse gas emissions. Biostimulants emerge as a game-changer, promoting plant growth and stress tolerance while minimizing environmental impact.

This article explores the role of biostimulants in vegetable farming, highlighting their benefits, mechanisms of action and potential to revolutionize modern agriculture.

What are Biostimulants?

Biostimulants are naturally occurring or man-made substances that improve plant physiological processes and enhance stress tolerance without directly providing nutrients. They come in various forms, including microbial inoculants, seaweed extracts, humic substances, and beneficial plant extracts. Biostimulants may be define as substances or microorganisms applied to plants with the aim of enhancing nutrient efficiency, stress tolerance, and crop quality. Unlike fertilizers that directly provide nutrients, biostimulants work by stimulating natural plant processes.

Mechanisms of Action of Biostimulants

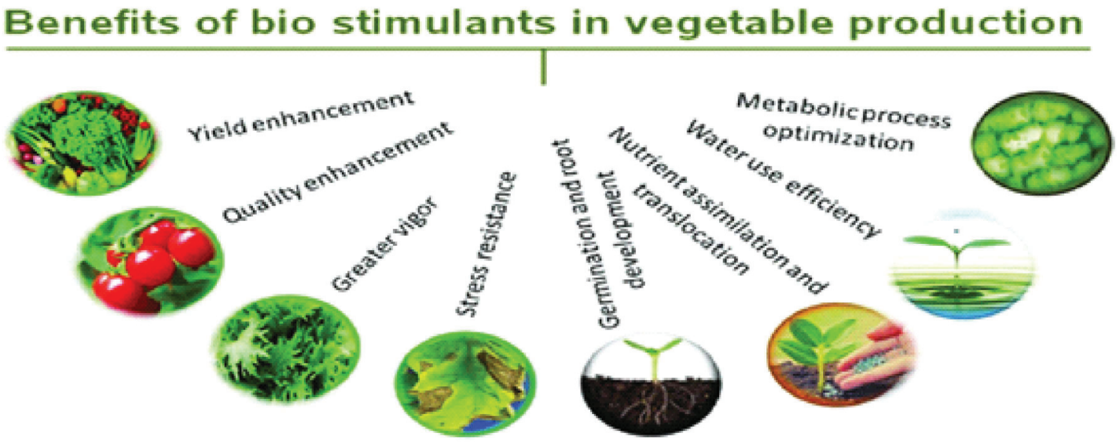
The exact mechanisms of biostimulants vary depending on the specific type. Here are some key ways they influence plant growth and stress tolerance

- **Enhancing Nutrient Uptake and Utilization:** Biostimulants can improve root development and nutrient mobilization, making essential nutrients more readily available to plants.
- **Modulating Plant Hormones:** Some biostimulants influence the production and activity of plant hormones, leading to

improved growth, flowering, and fruit set. Biostimulants can influence plant growth and development by affecting the production and activity of plant hormones. Here are some examples:

- **Auxins:** Biostimulants may promote the production of auxins, which stimulate cell division, root growth, and stem elongation. Some seaweed extracts contain auxin-like compounds or can trigger the plant to produce more auxin.
- **Cytokinins:** Biostimulants can influence cytokinin production, which plays a role in cell division, shoot growth, and nutrient uptake. Specific seaweed extracts and some beneficial plant extracts are known to stimulate cytokinin production.
- **Gibberellins:** Certain biostimulants may enhance the production of gibberellins, which promote stem elongation, seed germination, and fruit development. Some microbial inoculants can influence gibberellin production in plants.

- **Promoting Photosynthesis:** Biostimulants can enhance chlorophyll production and photosynthetic efficiency, leading to increased plant growth and yield.
- **Stimulating Microbial Activity:** Microbial biostimulants can promote beneficial soil microbes that contribute to nutrient cycling, improve soil health, and suppress plant pathogens.
- **Alleviating Abiotic Stress:** Biostimulants can help plants cope with stress factors like drought, salinity, heat, and cold by activating stress-response pathways and promoting the production of protective compounds.
- **Membrane Permeability:** Biostimulants may influence plant cell membrane permeability, allowing for more efficient nutrient transport within the plant. Seaweed extracts are known to contain compounds that can enhance membrane function.



Benefits of Biostimulants for Vegetable Growers

Increased Crop Yields and Quality: Biostimulants can promote stronger plant growth, improved fruit set, and better fruit quality, leading to higher yields and marketable produce.

Enhanced Stress Tolerance: By improving plant resilience, biostimulants can help vegetables withstand environmental stresses like drought, heat and salinity, leading to more stable yields.

Reduced Reliance on Chemical Inputs: Biostimulants can potentially reduce the need for chemical fertilizers and pesticides, promoting more sustainable farming practices.

Improved Soil Health: Some biostimulants can stimulate beneficial soil microbial activity, which improves soil structure, fertility, and water retention.

Increased Profitability: By improving yields, quality and stress tolerance, biostimulants can contribute to higher profits for vegetable growers.

Improved Fruit Set and Development: Biostimulants can influence the production of plant hormones like gibberellins, promoting better fruit set and development.

Enhanced Quality Traits: Biostimulants may improve the color, size, sugar content, and shelf life of vegetables through various physiological effects on the plant.

Drought Tolerance: Stimulated root development, improved water uptake efficiency, and increased production of osmolytes can all contribute to better drought tolerance.

Heat Tolerance: Biostimulants may enhance antioxidant activity and promote heat shock proteins.

Types of Biostimulants and their Applications in Vegetable Farming

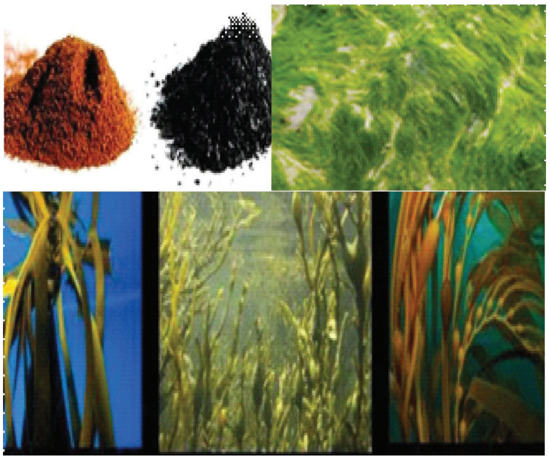
There are various types of biostimulants with specific applications in vegetable production. Here's a brief overview of some major categories:

Microbial Inoculants: These biostimulants contain beneficial bacteria, fungi, or other microorganisms that improve soil health, nutrient cycling and plant growth. Examples include nitrogen-fixing bacteria (rhizobia) and arbuscular mycorrhizal fungi (AMF). They are particularly beneficial for organic farming.

Seaweed Extracts: Rich in complex polysaccharides, seaweed extracts stimulate plant growth, improve stress tolerance, and enhance nutrient uptake. They are suitable for foliar application on various vegetables.

Humic Substances: Humic acids and fulvic acids improve soil structure, water retention, and nutrient availability. They are often used as soil amendments to improve overall soil health.

Beneficial Plant Extracts: Extracts from plants like aloe vera or yucca can stimulate plant defense mechanisms and improve stress tolerance.



Factors to Consider When Choosing Biostimulants

Crop Type: Different vegetables may respond better to specific types of biostimulants. Consider the specific needs of your target crop for optimal results.

Soil Conditions: Soil health and nutrient availability can influence the effectiveness of biostimulants. Analyze your soil and choose products that address any deficiencies.

Stress Factors: If your vegetables are prone to specific environmental stresses, select biostimulants known to improve tolerance to those stresses.

Biostimulant Application Methods: Achieving Maximum Efficiency

Biostimulants can be applied through various methods like foliar spray, soil drench, or seed treatment. Choose the most appropriate method based on the product and crop.

- **Foliar Application**

Directly sprayed onto plant leaves for fast absorption.

- **Soil Application**

Incorporated into the soil for gradual release to roots.

• **Seed Treatment**

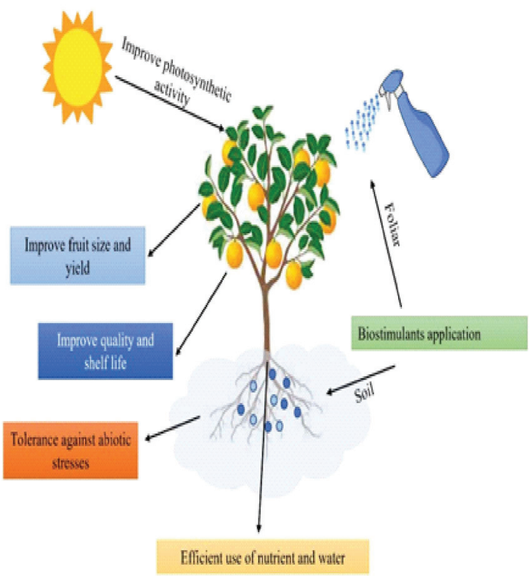
Applied to seeds before planting to promote germination.

• **Fertigation**

Delivered through irrigation systems for targeted delivery.

Each method has its own advantages and disadvantages. The choice of application method depends on the specific biostimulant, the crop, and the desired outcome.

Challenges and Future Directions of



Biostimulants in Vegetables

Challenges

o **Vegetable Specificity:** Research needs to focus on optimizing biostimulant use for specific vegetable crops to ensure consistent and reliable results.

o **Short-Term vs. Long-Term Effects:** More studies are needed to understand the long-term impact of biostimulants on vegetable production and soil health.

o **Integration with Existing Practices:** Developing strategies for integrating biostimulants with existing vegetable farming practices like fertilization and pest management requires further investigation.

o **Cost-Effectiveness:** Balancing the cost of biostimulants with the economic benefits for vegetable growers needs careful consideration.

Future Directions

o **Vegetable-Specific Biostimulant Development:** Research should focus on formulating biostimulants tailored to the unique needs of different vegetable crops for optimal performance.

o **Long-Term Studies:** Longitudinal studies are crucial to understand the cumulative effects of biostimulants on vegetable production and soil health over time.

o **Developing Integrated Management Programs:** Research should explore how biostimulants can be effectively integrated with existing vegetable farming practices for a holistic approach.

o **Economic Modeling:** Developing economic models that factor in yield improvements, input reduction, and long-term benefits can help demonstrate the cost-effectiveness of biostimulants for vegetable growers.

Biostimulants are emerging as a valuable tool in sustainable agriculture, offering a range of benefits for plant growth and development. Future research will focus on developing more effective and environmentally friendly biostimulants, expanding their applications in various crops and agricultural systems.

Conclusion

Biostimulants represent a transformative approach to enhancing vegetable farming. They offer a sustainable alternative to traditional agricultural inputs, promoting healthier crops and more resilient farming systems. As the industry evolves, increased research, awareness, and regulatory support will be crucial in unlocking the full potential of biostimulants, paving the way for a more sustainable and productive future in vegetable farming.

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Non- Thermal Technology for Food Preservation

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Introduction

The food processing company is characterized by thermal inputs for food conversion and/or preservation. However, thermal treatments typically result in negative alterations to the flavour, color, texture, and nutritional qualities of food, including the elimination of vitamins and proteins.Non-thermal processing techniques, on the other hand, are of interest to food scientists, manufacturers, and consumers because they prolong shelf life by suppressing or killing microbes while having no effect on the nutritional and sensory qualities of food. According to traditional methods, non-thermal food preservation techniques are thought to be more energy-efficient and to retain superior quality characteristics as by providing value-added products, fresh market prospects, and increased safety margins, non-thermal methods also satisfy the needs of the food industry. Various thermal treatments are applied to food during processing in order to extend its shelf life. However, food's nutritional value and sensory qualities candecrease as a result of these heat treatments. Human in nutritional requirement have evolved along with the worldwide change in lifestyle. Customers today demand food that is safe and hygienic without losing its nutritional value or flavor profile. Non thermal processing technologies are mainly used to increase the extraction of compounds through cell rupture and to prevent microbial growth, prolonging the shelf life of food, since, due to mechanical effects the cell membrane is damaged by the phenomenon of cavitation or electroporation. Recently non-thermal technologies have emerged significantly in the food sector. This led researchers in food processing to begin researching better alternatives, such as non-thermal treatments. Food is only exposed to room temperature for a very short while—less than five minutes in non-thermal processing, which results in no changes in food's nutritional composition, texture or mouth feel.

A. Ultrasound

High-frequency sound waves are utilized in ultrasonic packing technology to tightly seal package materials. When compared to more conventional sealing techniques like heat sealing and adhesive bonding, this approach is more advantageous due to its range of uses and efficiency. Although ultrasonication is a relatively recent non-thermal technology in the food sector, as it is an established technique in other processing industries. Ultrasound, to explain it simply, is a type of sound wave that possesses a frequency higher than that of human hearing, notably above 20 kHz.Ultrasonic waves generate many kinds of compression and expansion effects in the medium as they oscillate through it. The presence of air led to the formation of small cavities. Once the cavities achieve the required size, they collapse. Heat and mass transfer rates increase as result of the enormous energy and concentrated hot spots produced through these cavities bursting.Due to the increased heat and mass transfer caused by the ultrasonication effect, organic compound chemical synthesis can be faster and reaction yields can be increased. There are three types of ultrasonication: low-frequency, medium-frequency, and high-frequency. The frequency ranges for these types of ultrasonication are 20 kHz–100 kHz, 100 kHz-1 MHz and 1 MHz–100 MHz, respecti-vely. Large shear forces are produced in the medium by low-frequency ultrasonication, whereas small shear forces are produced by high-frequency ultrasonication. The formation of radical species occurs at the medium frequency, and this frequency range is thought to be ideal for a number of chemically assisted processes. However, the formation of chemical radicals may lead to undesirable changes in food, such as oxidative changes in proteins and lipids.

Basically, it is work as in the given process

i) The ultrasonic generator: Converts electrical energy into high-frequency sound waves (usually between 20 kHz and 40 kHz)

ii) The converter: Transforms the electrical signal into mechanical vibrations)

iii) The booster: Amplifies the vibrations to the desired level)

iv) The sonotrode: Delivers the amplified vibrations to the packaging material, creating friction and heat at the seal area.

Benefits of ultrasonic packing systems:

- **Strong and hermetic seals:** Ultrasonic seals are highly resistant to leaks and contamination, making them ideal for packaging sensitive products such as food, pharmaceuticals, and medical devices.
- **Fast and efficient:** Ultrasonic sealing is a high-speed process that can be integrated into automated production lines.
- **Clean and precise:** Ultrasonic sealing does not require adhesives or other consum-ables and it produces minimal heat and noise.
- **Versatile:** Ultrasonic sealing can be used with a wide variety of packaging materials, including plastics, foils, and laminates.
- **Environmentally friendly:** Ultrasonic sealing uses less energy and produces less waste than other sealing methods.

Techniques for Ultrasound

Ultrasound can be used for food preservation in combination with other treatments by improving its inactivation efficacy. There have been many studies combining ultrasound with either pressure, temperature, or pressure and temperature

- Ultrasonication (US) is the application of ultrasound at low temperature. Therefore, it can be used for the heat sensible products. However, it requires long treatment time to inactivate stable enzymes and/or microorganisms which may cause high energy requirement. During ultraso-und application there may be rise in temperature depending on the ultrasonic power and time of application and needs control to optimize the process
- Thermosonication (TS) is a combined method of ultrasound and heat. The product is subjected to ultrasound and moderate heat simultaneously. This method produces a greater effect on inactivation of microorganisms than heat alone. When thermosonication is used for pasteurization or sterilization purpose, lower process temperatures and processing times are required to achieve the same lethality values as with conventional processes

• Manosonication (MS) is a combined method in which ultrasound and pressure are applied together. Manosonication provides to inactivate enzymes and/or microorganisms by combining ultrasound with moderate pressures at low temperatures. Its inactivation efficiency is higher than ultrasound alone at the same temperature

• Manothermosonication (MTS) is a combined method of heat, ultrasound and pressure. MTS treatments inactivate several enzymes at lower temperatures and/or in a shorter time than thermal treatments at the same temperatures

Applications of ultrasonic packing systems

• **Food packaging:** Sealing bags, pouches, trays, and tubs for food products.

• **Medical packaging:** Sealing sterile pouches and blister packs for medical devices and pharmaceuticals.

• **Personal care packaging:** Sealing tubes, bottles, and jars for cosmetics and other personal care products.

• **Industrial packaging:** Sealing pouches, bags, and other containers for industrial products.

B. High pressure processing (HPP)

High pressure processing, or HPPis a food preservation method that inactivates harmful bacteria, viruses, and parasites in food and beverages by applying extreme pressure, typically from 3,000 and 6,000 bars (43,500 and 87,000 psi). As it is non-thermal-that is, it doesn't involve heat-food's flavor, original texture, color, and nutrients are preserved.The food industry appears to have identified High Pressure Processing (HPP) to be a viable technique. It has many advantages, such as increased food safety, longer shelf life, and little effect on food's nutritional value and sensory appeal. It does, however have several drawbacks, such as price and product appropriateness. It works as in given way

1) Food products are placed in a pressure vessel filled with water.

2) The pressure is gradually increased to the desired level and held for a specific time, typically a few minutes.

3) The pressure is then slowly released and the food is removed from the vessel. HPP is a relatively new technology, but it is becoming increasingly popular in the food industry. It is used to process a wide variety of foods and beverages, including Meat and poultry, Seafood, Fruits and vegetables, Dairy products, Juices and smoothies and Pet food etc. This effect is not noticeable in raw marinated meats. When HPP is used for meat extraction in seafood products, the protein structure is not altered since lower pressures are used (about 3,000 bar / 300 MPa / 43,000 psi). For over a century (e.g. Hite, 1899), high pressure processing (HPP), also known as ultra-high pressure (UHP) or high hydrostatic pressure (HHP), has been recognized as a potential preservation technique. For example, high pressure may delay the microbial deterioration of milk. Food pasteurization using hydrostatic high pressure has recently had resurgence due to advancements in science and technology. Japan, France, Spain, and the United States have already opened their markets to a variety of pressure-treated items. Foods whether in their packaging or not are

subjected to pressures ranging from 100 to 800 MPa during HPP. During pressure treatment, the process temperature might range from 0 to 100 degrees Celsius.

Advantages

• Food Safety Guaranteed. In order to comply with food authorities' regulations, HPP eliminates pathogens (such as Salmonella, E. Coli, Listeria, Vibrio, and norovirus) and spoiling microorganisms (such as lactic acid and bacteria).

• Minimal processing. Food products maintain their organoleptic properties and nutritional value. It offers foods with minimal or no processing while preserving the original product's freshness.

• Novel Opportunities for Markets. For certain items, like cured the meat, this is the only method that lets manufacturers reach safe markets in the US or Japan.

• Extension of Shelf Life. HPP ensures a high-quality product while extending the shelf life up to 3x to 30x, depending on the product and improve the efficiency of the supply chain.

• Innovative Products. HPP allows R&D teams to develop innovative products for the consumer and open new market niches.

• Increases the Extraction Yield of Shellfish Meat. HPP, at low pressures (3,000 bar), is used for opening bivalve mollusks and removing meat from crustaceans, increasing efficiency and minimizing labor.

• Eco-friendly. It requires electricity and water, which can be recycled.

Disadvantage

• Does Not Inactivate Spores. To be able to achieve this, a combination of pressure (6,000 bar) and temperature (>100ºC) would be needed.

• Sterilization is a technology capable of inactivating spores. Normally, the food industry uses high temperatures, achieving shelf stable food at room temperature for months or years. The drawback is that the high temperatures that are applied alter the nutritional and organoleptic properties of the food or drink.

• Currently, the combination of different technologies, including HPP, is being investigated to ensure the inactivation of spores, while still maintaining the characteristics of fresh food.

• Not Effective on Dry Products. To ensure its effectiveness, it is recommended that the products have an Aw (water activity) greater than 0.8.

• In certain cases, it is possible to develop alternative products or even modify certain aspects such as formulation or acidity to make the process efficient, even if the Aw is less than 0.8.

• Possible Changes in Texture or Color. Macromolecules such as proteins and polysaccharides change their three-dimensional structure with HPP. This can generate changes in texture and color on some products (meat, eggs or fish). However, there is no alteration in their composition or flavor.

This effect is not noticeable in raw marinated meats. When HPP is used for meat extraction in seafood products, the protein structure is not altered since lower pressures are used (about 3,000 bar / 300 MPa / 43,000 psi).

C. Pulsed X-Ray

Electrons have a limited penetration depth of about 5 cm in food, while X-rays have significantly higher penetration depths (60 - 400 cm) depending upon the energy used. Pulsed X-rays are generated using radionuclide sources that utilizes a solid state-opening switch to generate electron beam X-ray pulses of high intensity. The radionuclides Co-60 and Cs-137 are produced by neutron bombardment of Co-59 and Cs-136 as a fission fragment of a nuclear power reactor

Pulsed X-Ray

operation. They emit γ-radiation of discrete energy. These radionuclide sources require permanent massive concrete shielding to protect workers and the environment from their permanent radiation. Second approach is electrically driven radiation sources that switch off when the radiation is no longer needed are easier to incorporate into existing food processing plant. Linear Induction Electron Acceleration (LIEA) generates broad spectrum ionizing radiation by targeting the accelerated electron beam to collide with a heavy metal converter plate. This plate converts the electron beam in X-rays with a broad-band photon-energy spectrum. Then, by filtering the energy spectrum of the radiation, high-energy, highly penetrating radiation is produced, resulting in smaller variations in dose uniformity of food packages and higher quality.

D. Cold Plasma

Cold plasma is a state of matter where a gas is partially ionized. In order some of the gas molecules lose an electron, which leads to the creation of charged particles such as free radicals and ions. These charged particles interact with the packaging's surface when applied, producing a range of effects as

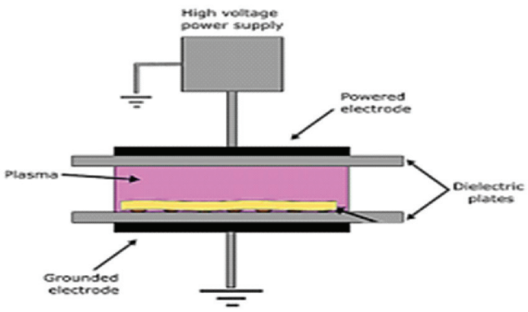
i) Direct inactivation of microorganisms: The charged particles disrupt the cell membranes of bacteria, viruses, and fungi, leading to their death.

ii) Chemical modification: The plasma creates reactive oxygen and nitrogen species which react with the packaging material, altering its surface properties. This can increase surface energy, improving adhesion and printability, or create antimicrobial coatings.

iii) Polymer crosslinking: In some cases, plasma can crosslink the polymer chains in the packaging material, enhancing its barrier properties and mechanical strength.A novel non-thermal technology called cold plasma shows lots of potential for use in the food industry. Earlier cold plasma was widely used for surface modification and functionalization of different polymers, mostly in the polymer and electronics industries. However, the use of cold plasma in medical devices and biological materials-including food-has increased significantly in recent years. There are various types of cold plasma generation systems used for different applications in the industry. They could range from corona discharges, microwave plasma, radio frequency plasma, inductively coupled plasma, capacity coupled plasma, electron cyclotron resonance plasma and dielectric barrier discharge plasma. Among these, dielectric barrier discharge and jet plasma are the most used for food research owing to their simple, versatile and adaptive designs and working. Plasma can be generated in any neutral gas by providing sufficient energy for its ionization making plasma chemistry much more complex. For example, air plasma consists of over 75 unique species and more than 500 chemical reactions happening at nano, micro, milli and seconds time scales.

Benefits

- **Broad-spectrum antimicrobial activity:** Effective against a wide range of microorganisms, including antibiotic-resistant strains.
- **Low-temperature process:** Doesn't damage heat-sensitive products or packaging materials.
- **Environmentally friendly:** No harsh chemicals or water required, reducing waste and environmental impact.
- **Versatility:** Works with various packaging materials like plastics, paper and biopolymers.
- Potential for extending shelf life: By reducing microbial growth and improving barrier properties.



E. Oscillating Magnetic Field (OMF)

Oscillating magnetic field is a magnetic field that changes its strength and direction over time. Unlike a static magnetic field, which has a constant intensity and direction, an oscillating magnetic field fluctuates, typically in a wave-like pattern. Oscillating Magnetic Fields (OMF) are used for their potential as microbial inactivation techniques. For SMF, the magnetic field intensity is constant with time, while an OMF is applied in the form of constant amplitude or decaying amplitude sinusoidal waves. The magnetic fields may be homogeneous (uniform magnetic field intensity) or heterogeneous (magnetic field intensity is inversely proportional to distance from coil) (USA-FDA Centre for Food Safety and Applied Nutrition (2011). OMF is used in the form of pulses reverses the charge for each pulse, and the intensity of each pulse decreases with time to about 10% of the initial [11]. Preservation of foods with OMF involves sealing food in a plastic bag and subjecting it to 1 to 100 pulses in an OMF with a frequency between 5 to 500 kHz at temperatures in the range of 0 to 500 C for a total exposure time ranging from 25 to 100 milli-seconds. Frequencies higher than 500 kHz are less effective for microbial inactivation and tend to heat the food material [11]. Magnetic field treatments are carried out at atmospheric pressure and at moderate temperatures. The temperature of the food increases 2-5 0 C (USA-FDA Centre for Food Safety and Applied Nutrition (2011). Studies have proposed two theories to explain the inactivation mechanisms for micro-organism and pathogenic cells placed in SMF or OMF. The first theory states that OMF loose the bonds between ions and proteins. Many proteins vital to the cell metabolism contain ions such as enzymes, hormones, pre-cursors which get damaged by OMF. A second theory considers the effect of SMF and OMF on calcium ions bound in calcium-binding proteins, such as calmodulin. Changing magnetic field to calmodulin causes cyclotron resonance resulting in loosening of the bond between the calcium ion and the calmodulin. This ultimately causes metabolic disorder followed by cell death.

There are different ways the magnetic field can oscillate

Sinusoidal: This is the most common type, where the strength of the field varies smoothly like a sine wave, reaching a peak value and then decreasing in a predictable pattern.

Pulsed: This type involves short bursts of strong magnetic field followed by periods of no field or a weaker field. The pulses can be regularly spaced or occur in a more complex pattern.

Principle:

Changing Current: The most common way to create an oscillating magnetic field is by using electricity. By running an alternating current (AC) through a coil of wire, the magnetic field generated by the coil also alternates. As the current direction and strength change in the wire, the magnetic field it produces follows suit.

Frequency and Amplitude: The rate at which the magnetic field oscillates is called its frequency, measured in Hertz (Hz). A higher frequency means the field changes direction more rapidly. Additionally, the strength of the magnetic field during its oscillation is called its amplitude.

F. Pulse Electric Field

Pulse electric field (PEF) is a non-thermal food processing technique that utilizes short, high-voltage electrical pulses to treat food products. These electrical pulses create temporary pores, or holes, in the cell membranes of microorganisms, plant and animal cells. This disruption can inactivate harmful bacteria and other pathogens, while minimally affecting the overall quality of the food. It is also defined as processing is a new food pasteurization method that uses short bursts of high voltage electric fields on foods to achieve desired microbial inactivation or modification of food structure.

Benefits

Preserves nutrients: Unlike heat-based methods, PEF processing minimizes damage to heat-sensitive vitamins, minerals, and other beneficial compounds in food.

Maintains freshness: PEF can help to retain the original texture, color, flavor, and aroma of food.

Extends shelf life: By inactivating spoilage microorganisms, PEF can extend the shelf life of food products.

PEF technology is still under development, but it has a number of promising applications in the food industry, including

- **Microbial inactivation:** Inactivating bacteria, viruses, and parasites in liquid foods like juices, milk, and beer.
- **Extraction enhancement:** Increasing the efficiency of extracting valuable compounds like juices, colors, and flavours from fruits and vegetables.
- **Tenderization:** Improving the texture of meat products.
- **Enzymatic activation/inactivation:** PEF can be used to activate or inactivate specific enzymes in foods, which can be useful for processes like fermentation or juice clarification.

PEF Machine

PEF's Current Uses in the Food Industry

Keeping it fresh: PEF zaps harmful bacteria in liquid and creamy foods like juices and yogurt, all while keeping their taste and nutrients intact. This technology has been used in commercially available juices since 2005.

Unlocking hidden treasures: PEF can gently coax out valuable juices, colors, and flavors from fruits, vegetables, and herbs. Think of it as a key that opens hidden goodness.

Potato power-up: PEF is a secret weapon for potato processors, especially those making French fries. It helps create perfect cuts, prevents breakage during cooking, and even offers some eco-friendly perks:

- Less water and energy used
- Faster drying and pre-frying times
- Fries that soak up less oil (meaning less fat!)
- More juice extracted from potatoes
- Less waste produced

In short, PEF is a cutting-edge technology that's making food processing more sustainable and tastier.

How PEF Works?

PEF processing applies high voltage pulses (20–80 kV/cm) with a duration of milliseconds to microseconds to treat liquid foods placed between two electrodes for solid foods, 1–8 kV/cm is used due to the large gap in the treatment chamber and the power limit of the pulse generator. The electric field may be applied as exponentially decaying, square wave, bipolar or oscillatory pulses at ambient, sub-ambient, or slightly above-ambient temperatures. The pulses are applied at high repetition rates (up to 3,000 pulses per second) so that the entire volume of the food sample can be treated.

PEF pre-treatment of potatoes had more benefits

- Enhances extraction of juice yields from fruits
- Reduces water and energy consumption
- Reduces the solid volume (sludge) of wastewater
- Shortens drying and pre-frying times
- Reduces frying oil absorption and fat content up to 50%

G. Hurdle technology

Hurdle technologies use a variety of techniques, some of which may work in combination with low heat to preserve food. In addition to the abovementioned and other technologies, hurdle technologies include the use of MAP, active packaging, cryogenic frightening antioxidants, ozonation, and enzymes. Due to the elevated CO2 level in MAP packaging, it provides a significantly longer shelf life than conventional packing. Other gases may be introduced, and O2 is frequently decreased. There is a microbistatic impact from the CO2. Food goods that are packaged need to be maintained at or below 5°C when using MAP. In order to prevent product deterioration or microbiological growth, active packaging can be enhanced by adding absorbing or releasing agents that regulate oxygen, moisture, carbon dioxide, and Odors. It is possible to quickly cool a product via cryogenic cooling and freezing, which will increase its shelf life. Hurdle technologies are being researched to get rid of germs in goods like apple cider, grape juice, mango juice, and tomato juice. They may also use combinations such antimicrobials, relatively high temperatures (<55°C), and PEF to produce a synergistic effect. A hurdle technique was used in Gauri Mittal's research, with 44°C as the temperature, pH 3.5 acidity, 80kV/cm PEF, and 100U nisin/ml. Without the use of aseptic packaging, they were able to accomplish a 6 log reduction in orange juice with a 28-day shelf life. In addition, gas chromatography analysis indicated no apparent alterations in the aromatic components. Antioxidants have shown potential in reducing and delaying lipid oxidation as used as barriers. It has been demonstrated that combining antioxidants from plant extracts with radiation can lessen oxidation in chicken and lessen the taste of warmed-over ground beef. In addition to their antibacterial and antioxidant properties, enzymes can also be used to inactivate or inhibit the activities of other enzymes in non-thermal food preservation techniques. In addition to its ability to prolong shelf life and maintain freshness when used in conjunction with other non-thermal preservation techniques, packagi-ng is an important non-thermal preservation method. Therefore, hurdle technologies seem to be the most effective way to get outcomes that the non-thermal technologies by themselves have not been able to attain.

Conclusion

The realm of food preservation is undergoing a revolution with the emergence of non-thermal processing techniques. Unlike traditional methods reliant on high heat, these innovative approaches offer a spectrum of possibilities for maintaining food freshness and safety without compromising taste or nutritional value. Consumers demand minimally processed, high-quality, convenient, and safe food products, prompting researchers to study non-thermal approaches. Non-thermal methods preserve color, flavour, texture, nutrients, and functional aspects while extending shelf life without the need for additives or preservatives. The potential for combining these technologies with established or newly developed food preservation methods is being investigated in order to increase the usage of non-thermal processes in the food sector. This work has explored various non-thermal processing techniques, including (mention specific techniques you covered, e.g., high-pressure processing, pulsed electric fields, ultraviolet light). Each technique possesses unique strengths and applications. For instance, (mention a specific example with benefits, e.g., PEF excels at inactivating bacteria in liquid foods while preserving taste and vitamins). The exploration of non-thermal processing techniques holds immense promise for the future of food. These methods not only enhance food safety but also cater to the growing consumer demand for fresh, minimally processed, and nutritious options. Further research and development in this field are crucial to optimize existing techniques and explore novel approaches. By harnessing the potential of non-thermal processing, we can revolutionize the food industry, ensuring a future where freshness and safety go hand in hand.

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Precision Agriculture: Emerging Technology of Sensor in Horticulture Farming

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Introduction

Precision agriculture, though the concept is not a new thing, the terminology itself and its practical implementation in the global agriculture sector is of comparatively recent origin, dating back to the 1980's. While this technology is widely available for field crops such as maize, soybean and grains, few yield sensing systems exist for horticultural crops such as berries, field vegetables or orchard crops. Nevertheless, a wide range of techniques have been investigated as potential means of sensing crop yield for horticultural crops. This article delves deeper into the afore-mentioned subject through reviewing such yield monitoring approaches and particularly throws light on the emerging technology of sensor use for enabling smart decision making in horticulture farming.

Precision agriculture is a technology driven management approach or philosophy to the cultivation of crops that takes into account the spatial and temporal variation in soil, crop and environmental parameters, and aims at enhancing productivity, maximizing profitability and protecting environment through efficient use of inputs. As a matter of fact, it is also known as site specific farming, smart farming and GPS based farming (Palaniappan, 2002) and VRT i.e. Variable Rate Technology (Sahoo *et. al.*, 2002). A sensor is a device that can sense the measured information and transform it into an electrical signal or other required forms of information output according to a certain rule to meet the requirements of information transmission, processing, storage, display, recording, and control. This data allows farmers and horticulturists to make informed decisions about when and how to plant, irrigate, fertilize, and harvest crop.

Types of sensors

1. Optical sensors

The optical sensors began to be studied in 1991 with the development of sensors focused in weed detection at the Oklahoma State University; based on the fact that the soil and plants (weeds) have a different interaction with the light emitted from the sensors, which allows them to identify what is soil and what is a plant. It uses multiple light frequencies to measure the qualities of the soil. These sensors, which are mounted on cars or drones, enable the collection and processing of information about plant colour and soil reflectance. Clay, organic matter, and soil moisture content can all be measured by optical sensors.

2. Electronic Sensors

It is mounted on tractors and other outdoor machinery to inspect equipment performa-nce. The information is then instantaneously transmitted to computers or sent via email to others using cellular and satellite connection networks. The information can then be retrieved by the field executive using their office computer or mobile device.

Drone and UAV Sensors Drones equipped with various sensors, including cameras and multispectral sensors, provide a bird's-eye view of fields. They are used for crop scouting, pest and disease detection, and generating field maps.

3. Agricultural Temperature Sensors

Temperature Sensors are crucial in two key categories of smart agriculture-ambient condition monitoring and mechanical asset monitoring. Ice wine harvesting, for example, is known to occur within the narrow temperature window when ambie-nt temperatures first reach between -10°C and -12°C during a harvesting season. Highly accurate temperature and humidity sensors and precise predictive temperature forecasts are imperative to the ice wine industry. Temperature sensors not only play a significant role in monitoring the ambient conditions of physical space, but they play an essential role in nearly all smart agriculture asset monitoring applications.

4. GPS Sensors

On the mechanical side of agriculture, plant harvesting and related farming techniques have recently adopted GPS technology in highly precise vehicle guidance systems. In many farming applications, such as tilling a field, the use of auto-guided systems can optimize field routing, reduce process overlap and ultimately reduce the amount of time required to complete a task.

Significance of sensors: The application of sensors in agriculture has in a way revolutionized how farming is practiced. Its significance particularly in the field of horticulture farming with suitable instances has been elaborated briefly.

The application of sensors in agricultural machinery, i.e., the use of machine vision, provides numerous information on soil condition, plants, pests, and weeds. The data collected in that manner enables an optimal use of resources, thus effectively serving the purpose of precision agricult-ure. Significance of sensor technology in several practices of precision agriculture has been highlighted as follows.

a. Irrigation Management: Soil moisture sensors, combined with weather data, help farmers optimize irrigation schedules. This prevents both excess or under application of water, which can lead to wastage of water and crop stress. Crop water stress map acts as blueprint to match irrigation to site specific crop demand. For instance, infrared thermom-eter sensors mounted on a centre pivot irrigation machine can be used to examine spatial variation in water stress of maize, grapefruit trees in particular. Besides, in accordance with the requirement of water saving irrigation in precision agriculture, an instrument was developed for measuring soil moisture content and its position. The instrument consists of a single-chip microcomputer, a GPS receiver, a SWR2 moisture sensor, a keyboard, an LCD display and the RS-232C communication interface to create distribution map of soil moisture for a scientific basis for precision irrigation. For irrigation management, variable rate of irrigation systems primarily with sprinkler irrigation and site-specific need-based fertigation or only irrigation by drip irrigation method is mainly followed.

In this regard, we can take the case of Jain Irrigation Systems Limited, headquartered at Jalgaon, Maharashtra, India; which is a diversified agricultural conglomerate with a turnover in excess of US$ 1.2 Billion. It primarily focuses on irrigating crops like apple, grapes, banana, sugarcane, tea, coffee, cotton, mango, teakwood, vegetables, flowers etc., using Micro Irrigation System made from high quality virgin raw materials, using advanced machinery. It is durable, reliable and meets international quality standards.

Last year, during their visit to the CRIDA Farm as a part of a G20 summit, international delegates observed the successful cultivation of a variety of crops under different MI systems, demonstrating the efficacy and adaptability of these cutting-edge technologies. The crops and MI systems showcased included:

Under Online System: Sweet orange, Papaya, Banana, Drumstick

Under Inline System: Tomato, Chilli, Brinjal, Red okra

Under Laser Spray: Onion, Radish, Beet root

Under Mini Sprinklers: Various leafy vegetables.

b. Nutrient Management: Sensors can monitor soil nutrient levels, allowing for precise application of fertilizers. This reduces the risk of nutrient runoff into water bodies and minimizes the cost of excess fertilizer use. Variable rate of fertilizer application has the potential to improve fertilizer use efficiency, and it sometimes also includes the application of soil amendments, added with an intention of correcting soil reaction. In this regard, it is to be mentioned that the first practical application of precision farming on a large scale started with liming. A majority of research in variable fertilizer application has focused on either developing "nutrient budgets" for a crop based on pre-sowing soil nutrient levels and crop nutrient uptake or identifying similar regions within a field, termed as "management zones" from both spatial and temporal data sources.

Creating management zones for variable rate strategies

Yield maps can be used on their own or in combination with other spatial data (e.g., soil maps or canopy vigour maps) to define field management zones, which can in turn be used as the basis for site-specific management (Hornung *et.al.*, 2006). Multiple years of yield data can be combined to help identify spatial yield patterns that are relatively constant over time (Blackmore *et. al.*, 2003; Leroux *et. al.*, 2018).

A sensor-based site-specific N topdressing strategy of bok choy

Determining the correct amount of topdressing N is a critical step toward enhancing NUE and ensuring the productivity and quality of vegetable crops (Zhou *et al.*, 2017). However, the complicated canopy architecture and the relatively short growth cycle of bok choy (Brassica rapa subsp. chinensis) and other vegetables relative to that of grain crops (e.g., corn and rice) has caused difficulty in determining the proper timing and amounts of topdressing N for vegetables (Lukina *et al.*, 2001; Barker and Sawyer, 2010; Lofton *et al.*, 2012b; Ali *et al.*, 2014; Xia *et al.*, 2016). An average organic fertilizer application rate used by local farmers (about 45 kg N ha-1) from manure was applied as the basal fertilizer to all treatments as part of the total N input and, thus, the amount of topdressing N could be quantitatively assessed and the sensor-based NFOA was used in our study to establish the amount of topdressing N fertilizer at the rosette stage of bok choy, and the recommended N-fertilizer strategy was thus proposed for the Taihu Lake region (Zanão Júnior *et al.*, 2005; Zhu, 2006; Yao *et al.*, 2012). According to preliminary estimation, the sensor-based topdressing strategy could reduce the total N input by 18.16-32.65% without sacrificing yields over traditional farming practices, which is consistent with findings for rice, where site-specific sensor-based N management increased the partial factor productivity of farmers by 48% without significantly affecting grain yield (Li *et al.*, 2009).

c. Disease management: Plant diseases are one of the primary causes of crop loss and damage globally. It threatens the farmer's income by increasing the production cost and reducing the quality of the agricultural products but nowadays, the technology is not limited to remote sensing and disease detection but uses Artificial Intelligence (AI) and Machine Learning. This allows us to identify plant diseases with little work and primarily by automated methods. Besides, an important step towards variable rate application of plant protection agents is the development and operating of online sensors for the detection of plant mass or leaf area index.

For instance, in the research article "Detection of Apple Lesions in Orchards Based on Deep Learning Methods of CycleGAN and YOLOV3-Dense", Y. Tian *et al.*, propose an anthracnose lesions detection method based on YOLO-V3 deep learning and DenseNet. The authors confirmed a dataset of 140 anthracnose apple images and used CycleGAN to learn the features of apple lesions images and transplanted to healthy apple images and 500 healthy apple images. The authors conclude that the classification performance of the proposed method, compared with several state-of-art deep learning methods, presents the highest detection accuracy (95.57%).

d. Pest management: Mapping field infestations of different pests gives the farmers about the option of applying suitable insecticides variably across their fields. The efficiency of field monitoring for insect pests would be improved with the knowledge of reflected solar radiation from crop canopies during insect outbreaks. However, there is much need for development of new insect management interventions that are economical and environment friendly.

In the research article "A Benchmarking of Learning Strategies for Pest Detection and Identification on Tomato Plants for Autonomous Scouting Robots Using Internal Databases", A. Gutierrez *et al.*, present the comparison of two different approaches for pest detection on tomato plants based on learning strategies. A solution that combines computer vision and machine learning is compared against a deep learning solution. The authors conclude that deep learning technique is a better solution than the combination between computer vision and machine learning; this conclusion is based on the analysis of 4,331 original pictures converted into 54,743 images of different insect and eggs of *Trialeurodesvaporariorum* and *Bemisiatabaci*.

A practical example is of 'Candidatus Liberibacter solanacearum' (CaLsol), which is a bacterium limited to the phloem of plants and haemolymph of insect vectors that is associated with zebra chip disease in potato and vegetal disorders in Apiaceae. Although transmission of the disease occurs mainly by psyllid insect vectors, it can also occur by grafts or seeds. In Europe, this pest is causing damage mainly in carrot crops, but also in potatoes, celery, parsnips, parsley, or fennel. In Spain, the damage is caused mainly in carrot crops.

The use of remote spectral sensors to monitor crops can help in this regard to study large areas of land with high resolution to detect plant diseases. These techniques can be performed at different scales, depending on the area to be monitored and the spatial and spectral resolution needed. On a large scale, the use of spectral data provided by satellites has been used for several decades, offering a large amount of spectral information but with little spatial resolution. On the other hand, unmanned aerial vehicles (UAVs) are becoming increasingly popular for rapid crop-level monitoring at any time. At the plant and leaf levels, spectral information can be gathered at high spatio-temporal resolution using manual sensors or mounted on agricultural vehicles or fleets of autonomous robots.

e. Weed management

It lays stress on the aspect of target-oriented application of spraying fluid, i.e., spraying only at those sites where weeds have grown beyond the critical level as defined by the grower. Weed patches, crop growth parameters and soil properties vary spatially and hence the efficiency and fate of herbicides also vary. The basic idea is to involve practices that reduce herbicide application. For example, night tillage can be effective in controlling germination of weed species for which germination is light induced. Patch spraying or intermittent spraying of herbicides, utilization of prescription maps for pre-emergence weed control and air borne optical remote sensing is useful for detecting weed infestation. The key idea is that areas with weeds have lower brightness values than areas without weeds. Weeds can also be classified or differentiated based on remote sensing technique in which the multispectral digital imagery was acquired using a 4-band CCD array camera (1320 by 1035 pixel array) with sensors detecting 540 nm, 695 nm and 840 nm.

f. Controlled climate monitoring: In controlled environment agriculture systems like greenhouses and vertical farms, sensors are vital for maintaining optimal conditions. They regulate temperature, humidity, and light to create an ideal growth environment for crops. Precision Farming Development Center, ICAR-CISH, Lucknow has demonstrated the off season production of high value vegetables like tomato, cherry tomato, coloured capsicum and parthenocarpic cucumbers under polyhouse. The yield was enhanced to a substantial level by growing tall indeterminate hybrids and adopting good management practices. The temperature reduction of 5-7 ^{o}C along with RH enhancement of 35-60% during summers and temperature increase of 3-5 ^{o}C and RH reduction up to 25-35% RH during winter in the polyhouse was observed.

The positive influence of polyhouse on the morpho-phenological and physiological events of the high value crops viz., tomato, coloured capsicum, parthenocarpic cucumber, strawberry, melons during winter and cut flowers is depicted on the enhancement in the duration of the crop under the controlled conditions.

Tomato Varieties: Hybrid varieties with indeterminate growth habit are suitable for greenhouse cultivation. For example: Naveen (Indo American), Sartaj (Beejo Sheetal), Avinash II (Syngenta),Himsona (Syngenta),Himshikhar (Syngenta), etc.

g. Grading and Yield Prediction: Data from sensors can be used to classify or differentiate various crop grades and predict crop yields with greater accuracy. This information is valuable for planning harvests, storage, and marketing.

6. Research and Innovation: Sensor data provides valuable insights for agricultural research, primarily to study the crop growth pattern or processes involved. Researchers can even use this data to develop new crop varieties, cultivation techniques, and pest management

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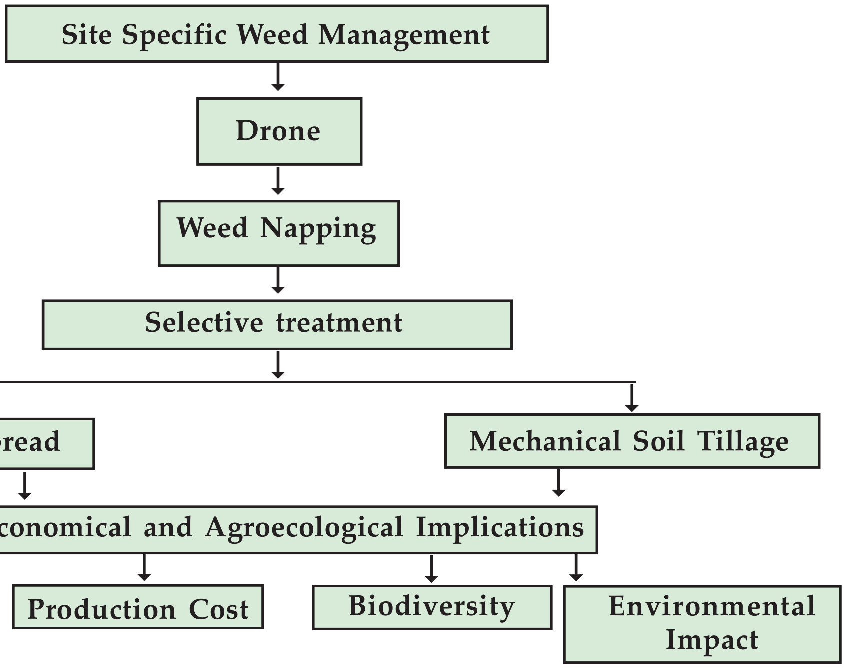
strategies. For instance, in the research article "Non-destructive Quantification of the Ripening Process in Banana (Musa AAB Simmonds) Using Multispectral Imaging", M. Santoyo-Mora et al. propose a non-destructive technique based on the processing of multispectral images to evaluate the ripening process of a banana (Musa AAB Simmonds) at the seventh stage of the growing process.


Temperature sensor

GPS sensor


Optical Sensor for Nitrogen Requirement Detection



Drip irrigation for precise irrigation management in English Cucumber farming

Optical Sensor for Weed Detection

Conclusion

These sensors are the transducers that collect the data on climatic condition, soil moisture and fertility, root & shoot growth; profuse leaf growth, photo-period monitoring, floral & seed setting, grain/fruit bearing, pest and diseases as critical growth factors symptoms and harvest readiness. Use of sensors and precision farming in horticulture aims at increasing productivity, decreasing production costs and minimizing the environmental impact of farming. Though it is widely practiced in developed countries, is still at nascent stage in most of the developing countries which needs integrated and sustainable efforts.

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For the welfare of the Farmer's, the society "Society for Advancement in Agriculture, Horticulture and Allied Sectors" willing to publish E-magazine in the name of "Krishi Udyan Darpan E-Magazine (Hindi) / **Krishi Udyan Darpan** E-Magazine (English**, Innovative Sustainable Farming**.)**, which covers across India.**

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All authors submitting articles must be annual or Life member of **SAAHAS, Krishi Udyan Darpan** E-Magazine Hindi / **Krishi Udyan Darpan** E-Magazine English**, (Innovative Sustainable Farming**). Articles must satisfy the minimum quality requirement and plagiarism policy. Author's can submit the original articles in Microsoft Word Format through provided email, along with scanned copy of duly signed **Copyright Form**. Without duly signed Copyright Form, submitted manuscript will not processed.

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16. Submitted manuscript are only running article and contains the field of Agriculture, Horticulture and Allied sectors.
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ABOUT THE SOCIETY

Father of Nation Mahatma Gandhi's concept of rural development meant self-reliance, and least dependence on outsiders. India is an agrarian country and about 65% of our population lives in rural areas. But unfortunately, most of us do not have any idea about the extent of poverty and the real conditions of rural India.

With the purpose of serving the agricultural fraternity and farming community the Society for Advancement in Agriculture, Horticulture and Allied Sectors (SAAHAS) was founded in 2020 (under Society Registration Act, 1860). Among multifarious ways of serving farming community we are involved in training of the farmers by organising technology dissemination programmes in villages, guiding them to adopt good agricultural practices involving planned crop management. It helps in reducing farm base losses and motivating them to become farmer level entrepreneur rather than a simple producer. It involves initiating skill based knowledge to the student of agriculture, horticulture and allied sectors to encourage them to serve the farmers in the best possible ways.

SAAHAS calls us to look into the genuine problems of farmers and address those issues for their betterment in the arena of Agriculture, horticulture and allied sectors. Besides agriculture, horticultural crop production has been given a major focus by Govt. of India in future crop diversification, improving livelihood through doubling farmers' income, economic opportunities through export and job opportunities. While good beginning is made, much is to be achieved in different areas in agro-horticulture sector.

Apart from that, SAAHAS helps developing the culture to involve more number of women in farming, processing of crops and value addition thereof for higher returns in terms of total income. SAAHAS eagerly involves with the farmers and agriculture entrepreneur to motivate them for introducing hi-tech farming, which includes growing of high value horticultural crops in hydroponics, aeroponics, polyhouse, net house and greenhouse. The society has geared up its activities to take up the challenges of biotic and abiotic stresses, emerging needs of quality seeds and planting material and reducing cost of production.

There are several government and non-government organisations intended of farmer's welfare; still there is dire need for more involvement and attachment with the farmers. Our society's noble initiative can ensure diminishing of the persistent gap between agro-technocrats, scientists with the needy farmers. We not only ensure that the farmers choose right variety of right crop, better nutrient management through diagnosis recommended system and pest diagnosis but we also help them to sale their produce at premium rates. There is a major issue of chemical residues in food, soil and ecology which is also a big concern of the century. The Society also aims to motivate the farmers either for minimal use of chemical inputs or total adoption of organic farming. Consultancy, training, awareness programs, national and international seminars and symposia and technical services are the prime activities of the SAAHAS.

Society for advancement in Agriculture, Horticulture and Allied Sectors publishes peer reviewed scientific journal, 'Journal of Applied Agriculture and Life Sciences (JAALS)', biannually since January 2020 focusing on articles, research papers and short communications of both basic and applied aspect of original research in all branches of Agriculture, horticulture and other allied sciences. To apprise the scientists and all those who are working in the field of Agriculture, horticulture and allied sectors about recent scientific advancement is the aim of the Journal.