Open Access Multidisciplinary Online Magazine

Agri-India TODAY

Monthly e-Newsletter

ISSN : 2583-0910

Volume 04 | Issue 12 | December 2024

www.agriindiatoday.in

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/01/1224

UTILISATION OF SEAWEED FOR HUMAN HEALTH

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Abstract
Because of the seaweeds' rich nutritional profile, bioactive chemicals, and environmental advantages, their use has drawn a lot of interest from a variety of industries. The many uses of seaweeds are examined in this abstract, with a focus on the culinary, medicinal, cosmetic, agricultural, and environmental sectors. Seaweeds are prized in the food industry for their high vitamin, mineral, and antioxidant content, which makes them useful additives in food items, particularly for improving the quality and shelf life of seafood and fisheries goods. Seaweeds also contribute significantly to the pharmaceutical and cosmetic industries by supplying bioactive ingredients for anti-inflammatory, skincare, and health supplement products. Additionally, by aiding in carbon sequestration, coastal preservation, and biodiversity conservation, seaweed farming promotes sustainable practices. Seaweeds are used in agriculture as animal feed and biofertilizers, encouraging organic farming and lowering the demand for artificial chemicals and fertilisers. The rising interest in seaweeds as a sustainable and adaptable resource is highlighted in this overview, along with how they may help with global issues including environmental preservation, food security, and sustainable economic growth. To investigate new uses and maximise seaweed production for a greater variety of industrial applications, further research is necessary.

Keywords: Seaweed, Health, food industry, cosmetic industries and animal feed

Introduction

Every ocean is home to a large number of seaweeds, which are marine photosynthetic algae. Seaweed is divided into three major groups, or phyla: Rhodophyta (red algae), Chlorophyta (green algae), and Phaeophyceae (brown algae). There are thousands of species in each phylum. Seaweeds have long been used as fertilisers, colours, food, and traditional medicines. Seaweed components were used in industry when mass food production emerged in the early 1900s. Because of their ability to gel in food, medicine, and biotechnology applications, hydrocolloids including agar, carrageenan, and alginate continue to be the most widely used ingredients (Zollman, 2019). Seaweed's aptitude for producing bio-diesel has been investigated in order to provide green fuel substitutes (Abomohra *et al.,* 2018). Seaweeds have gained attention as nutraceuticals, or functional foods, with nutritional advantages beyond their macronutrient composition throughout the past three decades. Furthermore, seaweed has been extracted for biologically active metabolites in order to create medicinal goods (Zerrifi *et al.,* 2018). In industrialised nations like the USA, Australia, and Europe, the paradox of obesity combined with vitamin and mineral deficiencies has turned into a health crisis. At the same time, disorders linked to nutrition and lifestyle-such as type 2 diabetes, cancer, and metabolic syndrome-have become more common. According to international dietary research, nations with regular seaweed consumption had far lower rates of obesity and diet-related illnesses (Nanri *et al.,* 2017). The study of seaweed alone for its advantageous nutritional and therapeutic benefits has prompted inquiry, even though a variety of dietary components may be implicated in this inverse association. Recent advancements in the use of seaweed as a functional food component and for human health from an epidemiological standpoint are described in this article.

Functional food applications of seaweed

Micro- and macronutrient profile

Since the dawn of human civilisation, coastal populations all over the world have used seaweed as a food source and forage (Dillehay *et al.,* 2008). Increased knowledge of dietary sciences and the nutrient-dense nature of algae have led to a recent trend of adding seaweeds or their extracts to dishes to enhance their nutritional qualities.

Minerals and vitamins

Some seaweeds contain 10 to 100 times more minerals and vitamins per unit dry mass than terrestrial plants or animal derived foods (Rupérez, 2002). These include fat- and watersoluble vitamins A, D, E, K, C, B1, B2, B9, B12 and essential minerals calcium, iron, iodine, magnesium, phosphorus, potassium, zinc, copper, manganese, selenium, and fluoride (Qin 2018). Content varies among species. For example, a study of five brown, eight red, and eight green seaweeds from northern European waters found that total tocopherol (vitamin E) content ranged from 1.6 to 122 mg kg^{-1} in brown, 10–26 mg kg^{-1} in red, and 8.8–12.0 mg kg^{-1} in green species (dry mass, DW) (Biancarosa *et al.,* 2018). From a portion perspective, taking 8 g (DW) as a typical serving size, many seaweeds perform better than plant and animal foods in terms of adult reference nutrient intake (RNI; Astorga-España et al. 2015). For example, the British Nutrition Foundation recommends 8.7 mg iron/day-1 for adult males.

Proteins

Proteins constitutes 5% to 47% of seaweed dry mass. Red seaweeds have the greatest protein content, while green has less, and brown the least (Cerna, 2011). About 42% to 48% of the total amino acids (AA) in seaweeds are necessary AA. With the exception of soy, which has a score of 1.0, the majority of seaweeds have a higher score than any plant-based protein on a scale of 0.0 to 1.0, where egg protein has a value of 1.0. For instance, *Laminaria saccharina*, has an amino acid score of 0.82, Pyropia/Porphyra 0.91, and *Undaria pinnatifida* 1.0, which is comparable to that of egg and soy (Murata & Nakazoe 2001). On the protein digestibility-corrected aa scale, seaweeds' high polyphenolic content, however, might make algal proteins less digestible, resulting in a somewhat lower score. Despite this, seaweeds still represent a viable alternative to animal-derived protein; if other high-aa scoring vegan foods, such as soy or mycoprotein, are included in the diet.

Polysaccharides

Seaweeds have a total polysaccharide or sugar content ranging from 4% to 76% (dry mass) (Paniagua-Michel *et al.,* 2014). Cellulose is an indigestible, non-nutritive polysaccharide that gives structure to the cell walls of many seaweeds and makes up 2% to 10% of total polysaccharides. The majority of algal polysaccharides are non-starchy fibre, which helps balance normal blood glucose levels and can contribute to the RNI of 30 g fibre day^{-1}. The structural chemistry of algal fibre is different from that of terrestrial plants, which gives them functional and bioactive properties not found in land-based fibre sources.

Lipids

Seaweeds have a total lipid content that varies between 0.60 and 4.14% (Rodrigues et al. 2015). Docosahexaenoic and eicosapentaenoic acids are among the (n-3, or omega3) fatty acids that make up the majority of polyunsaturated algal lipids. The most prevalent algal mono-unsaturated (n-6, or omega-6) fatty acids are linoleic and arachidonic acids (Belattmania et al. 2018). Myristic and palmitic acids are examples of principal saturated fatty acids. Although both n-6 and n-3 fatty acids are necessary from a nutritional standpoint, an unbalanced intake of them can lead to chronic inflammatory conditions such obesity, rheumatoid arthritis, non-alcoholic fatty liver, and cardiovascular disease. Over the past 20 years, the ratio of n-6:n-3 intake in industrialised, Western nations has increased to about 20:1. In order to prevent chronic illnesses linked to excessive intake of n-6 monounsaturated fat, a ratio of 2.5:1 to 4:1 (n-6:n-3) is often advised (Simopoulos 2016). Seaweeds are great dietary lipid sources because their fatty acid ratio of n-6:n-3 falls within this low range (Biancarosa et al. 2018). Beyond simple nourishment, some seaweed-specific nutrients such phycobiliproteins, phlorotannins, fucoxanthin, and sulphated polysaccharides have medicinal uses.

Incorporation in to food products

Meat-based products:

A staple food for billions of people throughout the world, meat is a rich source of protein, vitamins B, D, and A, as well as bioavailable iron, zinc, selenium, and magnesium. However, meats-especially beef and pork-contain high amounts of saturated fat, which can cause LDL cholesterol to rise. Burgers, frankfurters, salami, and deli-sliced meats are examples of meat-derived products that use salt as an essential element for preservation, flavour, and texture improvement. In addition, some producers use artificial flavourings and preservatives including sodium nitrate and monosodium glutamate, which have been connected to cancer and other illnesses (Cofrades *et al.* 2017).

Plant-based products:

With the exception of unprocessed fruits, vegetables, pulses, and rice, most plant-based (processed) items consumed worldwide are made from grains and are a staple of nearly every human population's daily diet (Stephen *et al.,* 2017). Thousands of various types of bread, pasta, noodles, and pastries are made from these grain- or cereal-based items. These foods have a high carbohydrate level but low fibre, protein, mineral, and vitamin content since most of them are made with refined white flour. As a result, adding high-fiber, nutrient-dense functional ingredients like seaweed to cereal-based products may help boost dietary intake of vital elements. Seaweed and its extracts have been effectively added to cereal-based products in a number of trials.

Epidemiological evidence and dietary intervention studies

Cancer

Seaweeds are regarded as food, not medication, by the European Food Safety Authority, the US Food and Drug Administration, and the European Pharmacopoeia. Seaweeds are marketed with information on their effects and usage instructions, nevertheless, and are regarded as therapeutic in many Asian nations. The Chinese Marine Materia Medica (CMMM) and the pharmacopoeias of Korea and Japan also include examples. Seaweeds and other marine species are included separately from terrestrial Materia Medica in traditional Chinese medicine. 171 species of therapeutic algae are included in the CMMM (Qin, 2018). The majority of epidemiological data may have originated in Asia, where seaweed has been used as a regular element of the diet and acknowledged as medicine for millennia (Kim, 2017).

Obesity and metabolic disorder

According to the Organisation for Economic Co-operation and Development, in 2015, 38.2% of American adults were obese, compared to just 3.7% in Japan and 5.3% in Korea. In many industrialised areas, obesity has turned into a health crisis when it is paired with vitamin and mineral deficiencies. According to Medina-Remón et al. (2018), obesity raises the risk of coronary heart disease, type 2 diabetes, hypertension, and dyslipidaemia, among other illnesses. Eating foods high in fibre, such as seaweed, and seaweed isolates, such as alginate and carotenoids, has been associated with improvements in blood sugar, cholesterol, appetite, and satiety (Brown et al. 2014). Diabetes type 2 In 1980, 108 million individuals worldwide (or 4.7% of the world's population) had diabetes. By 2014, this has grown to 422 million, or 8.5% of the world's population. Type 2 diabetes accounted for 90–95% of these diabetic patients. Type 2 diabetes is currently diagnosed in 7.7% of persons in the United Kingdom. It is 9.1% in the US, and 86 million people, or 26.4% of the population, are pre-diabetic. Unlike type 1 diabetes, an autoimmune disease that is frequently genetically inherited and requires insulin injections to treat, type 2 diabetes mellitus, also referred to as adult-onset diabetes, is a diet-related metabolic disorder that responds well to dietary intervention.

Properties

Antioxidants

Damage to living cells by free radicals, such as reactive oxygen species, is linked to many chronic disorders. Even though humans' natural defences may partially counteract oxidation caused by free radicals, many people still have an imbalance, particularly when their diet is deficient in antioxidants and they are under a lot of stress. According to epidemiological research, dietary substances like fucoxanthin and phlorotannins can lower the risk of developing conditions like metabolic syndrome, cancer, cardiovascular disease, osteoporosis, renal disease, Parkinson's, Alzheimer's, and neurodegenerative diseases that are linked to cellular damage caused by free radicals (Barbosa et al. 2014; Shannon et al. 2018). Antioxidant metabolites have been produced as a result of the environmental challenges that seaweed faces in their maritime habitat, including exposure to oxygen and UV radiation.

Antibacterial properties

Despite the invention of antibiotics in the 1940s, the prevalence of infectious diseases brought on by bacteria, viruses, fungus, and protozoa is still rising worldwide. The established immunity of microorganisms to pharmaceutical medications and disinfectants is the problem in the Western world, not the availability of antimicrobial therapies. Because they can grow and persist on surfaces and in human hosts, bacteria in particular are dangerous. Drug-resistant bacterial diseases, including Pseudomonas aeruginosa, Helicobacter pylori, Mycobacterium tuberculosis, Neisseria gonorrhoeae, Haemophilus influenzae, and methicillin-resistant Staphylococcus aureus (MRSA), now cause at least 700,000 deaths annually globally. Willyard 2017; Richter & Hergenrother 2018).

Conclusion

Seaweeds are a key resource for sustainable development because of the numerous advantages they provide for a variety of sectors. Seaweeds are valued in the food business for their nutritional content, which includes high concentrations of vital vitamins, minerals, and bioactive substances. Because of their antibacterial, preservative, and antioxidant qualities, they are also being investigated as functional additives to improve the quality and shelf life of fisheries products. Seaweeds supply bioactive chemicals utilised in medicines and cosmetics that may be utilised to create anti-inflammatory drugs, skincare products, and health supplements. From an environmental standpoint, seaweed farming is important for protecting coastlines and sequestering carbon, which helps to mitigate climate change and preserve ecosystems. Seaweeds are used in agriculture as animal feed and biofertilizers, which encourage organic farming methods and lessen dependency on artificial chemicals. The potential of seaweed to promote sustainable practices, improve product quality, and strengthen economic and environmental resilience is generally reflected in the increased interest in its use. Further creative uses will probably be made possible by ongoing research and development in this area, highlighting the significance of seaweeds as a flexible and sustainable resource.

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Article ID : 04/XII/02/1224

THE IMPACT OF SENSORS TECHNOLOGY IN MODERN FARMING

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Abstract

The emergence of sensor technology has significantly transformed agriculture by facilitating precision farming, which enhances efficiency, sustainability, and crop productivity. Sensors help give timely information on soil moisture, temperature, crop health, and weather, allowing decisions regarding farming to be made in real time, avoiding waste of the resource, and increasing production at a low cost. The variation of sensors counts on whether it is soil sensing, weather, or crop health all for controlling other sections of farming from soil conditions to early on detection of disease. However, sensor technologies present high initial costs, problems with data integration, and a requirement for technical skills. The above challenges need to be overcome with cost-effective solutions and training programmes to really capitalize on the potential of sensor-driven agriculture. This article discusses the merits, types, and challenges of sensor technologies in digital agriculture and their application in developing sustainable farm practices.

Keywords: Sensors, Smart farming, Digital agriculture.

Introduction

The integration of cutting-edge technology has brought significant transformation to agriculture, which remains the primary economic activity. Currently, new technology precision agriculture, digital farming, AI (Artificial Intelligence) that is rich in efficiency, efficacy, and sustainability (Mehta *et al*., 2020) is replacing farming practices that call for greater labour and traditional methods. The integration of tools like sensors and IoT devices is providing real-time data, enabling new technologies to make informed decisions instantly.

Modern agriculture is changing dramatically as a result of sensor technology, which is propelling the transition to more intelligent and precision farming (Singh *et al*.,2014) methods. Farmers may keep an eye on vital parameters like crop health, temperature, humidity, and soil moisture in real time by incorporating sensors into digital agricultural equipment. This constant flow of information makes it possible to manage resources more precisely, which raises agricultural yields, lowers input costs, and promotes sustainability. For example, soil sensors can detect moisture levels with accuracy, allowing farmers to irrigate crops only when needed, so avoiding misuse and preserving water. Similar to this, sensors that keep an eye on plant health can spot early warning signals of illnesses or nutrient shortages, enabling prompt and focused treatments. Because of this accuracy, less herbicides and fertilizers are needed, which is good for the environment.

In modern agriculture Sensor technology has got the potential to change Completely how agriculture is getting performed, as well as this might significantly progress intelligent and precision farming (Singh *et al.,* 2014). Digital agricultural equipment may include sensors; this allows farmers to monitor important values such as crop status, temperature or humidity and soil moisture in real time. Agricultural yields are boosted, input costs fall and sustainability is encouraged by managing resources more accurately thanks to the steady stream of information. In the field of agriculture, soil sensors can be utilized to track moisture levels with pinpoint accuracy and notify farmers when their crops need to be irrigated or watered, thus preventing overuse and saving this natural resource. Likewise, the sensors monitoring plant health can detect early symptoms of disease or nutrient deficiencies allowing fast and targeted.

Thus, it may be said that sensor technology is the most innovative of all the developments in modern farming. Farmers can more easily monitor crop health, soil conditions, weather, and irrigation needs in real time thanks to sensors. This shift to precision farming not only helps to make better use of the resources at hand, but it also helps to meet the rising projections for global food consumption. This article aims to provide a comprehensive understanding of sensor technology influences the development of digital agriculture.

Importance of sensors in agriculture

By giving farmers the critical detail about the status of their level of product, the irrigation method, the soil's health, and pests, sensors make the process of applying water, fertilizer and pesticides more precise. In addition to increasing the output of the crop, this personalized method considerably reduces input waste levels, to the advantage of both soil health and farmers' incomes. This makes it simple for farmers to modify irrigation schedules and times through the use of sensors that provide the best data on the soil moisture content on a particular farm in order to provide the crop with the necessary water at the most advantageous time. Additionally, sensors help detect diseases or insect invasions, which helps reduce losses and improve the quality of crops that are produced. (fig.1)

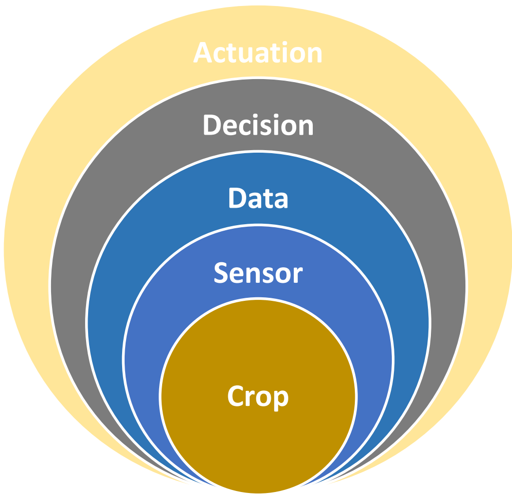


Fig.1 Process of data collection

Types of sensor technologies in agriculture

1. **Soil sensors:** Numerous soil characteristics, such as temperature, pH, moisture content, and nutrient availability, are tracked by soil sensors (fig.2a). By using this information, farmers may optimize resource use and increase crop yields by making well-informed decisions about planting, fertilizing, and irrigation techniques. By integrating temperature and moisture sensors, it is possible to gather information on whether irrigation is needed, allowing integration with irrigation systems. There are many sensors available that can measure the levels of nitrogen, phosphorus, potassium, and pH in the soil, enabling informed decisions about nutrient application.

2. **Weather sensor**:
   Weather sensors measure temperature, humidity, precipitation, and wind speed (fig.2b). For example, precise temperature measurements assist in determining when sowing and harvesting will suitable, ensuring crops grow in optimal conditions Preventive measures may be necessary if humidity levels indicate when irrigation should be applied or whether fungal diseases tend to occur. Precipitation data helps farmers to plan schedule irrigation (Kumar *et al.*, 2023) and conserve water resources. Further, wind speed measurements are important in determining when the application of insecticides and fertilizers is going to be performed because strong winds might cause uneven application and loss of fertilizer and chemical. The farmers can utilize real-time data provided by weather sensors to enhance the crop management method and reduce costs on operations whilst simultaneously improving overall productivity.
3. **Crop health sensor:** Crop health sensor (fig.2c) monitor crop conditions, identify problems such as diseases, pest infestations, and nutrient deficiencies, and enhance crop quality and productivity by utilizing multispectral, hyperspectral, NDVI, and thermal imaging technologies. These sensors assess fluctuations in reflectance, monitor light wavelengths, and identify changes in surface temperature. They can be installed on drones or stationary platforms for real-time data, help regulate irrigation, and identify stressed (Rajwade *et al.*, 2023) and healthy areas.
4. **Miscellaneous sensor**: By supplying crucial information, proximity, sound, gas, and pressure sensors (fig.2d) improve precision farming. They enable operations that enhance overall productivity and crop management, such as automated planting, gas monitoring, pest identification, and efficient irrigation.

Resistance soil moisture sensor | Capacitive soil moisture sensor | Soil Temperature Moisture EC PH Sensor

(a) Soil health sensors

DHT 22 Sensor | DHT 11 Sensor | Rain sensor | Wind speed and direction sensor | Water level sensor

(b) Weather sensor

NDVI sensor

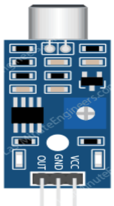
Thermal imaging sensor

Multispectral sensor

(c) Crop health sensor

Inductive proximity sensor

Gas sensor



sound sensor

Pressure sensor

Ultrasonic sensor

(d) Miscellaneous sensor

Fig2. Types of sensors

Challenges in implementing sensor technologies

The widespread application of sensor technology in agriculture is hampered by several issues. One of the biggest obstacles is the high initial price. Deploying sensor systems could be unaffordable, particularly for small-scale farms. Even while these technologies will eventually pay for themselves by enhancing output and efficiency, their initial cost remains a significant impediment. Another challenge is data integration and management. For farmers, collecting vast amounts of sensor data is not enough; they also need to handle, analyse, and interpret this data. Integrating sensor data with existing farm management systems can be challenging and often requires technical expertise and the appropriate equipment, which not everyone has simple access to. Additionally, **training and education** are essential for the effective use of these technologies. Many farmers, especially those in developing regions, may lack the technical skills needed to operate and maintain sensor-based systems. Therefore, comprehensive training programs are crucial to ensure that farmers can leverage the full potential of sensor technology in their agricultural practices.

Conclusion

Sensor technology helps farmers to obtain real-time data about the weather, crop health, and soil in precision farming. This innovation ensures that farmers avoid much waste concerning water, fertilizers, and pesticides while maximizing resource use, ensuring higher yields, and promoting sustainability. However, it has hurdles such as its high price, difficulty in handling the data involved, and technical expertise are needed. As it turns out, each of these issues with problems can be overcome by training, data integration, and affordable solutions for deployment even by low-intensity farmers. In the end, sensor technology is essential to contemporary farming, supporting sustainable agricultural methods and helping to meet our globally expanding food requirements.

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/03/1224

SUCCESS STORY ON DOUBLING FARMER'S INCOME IN THE TERAI REGION OF WEST BENGAL

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Introduction

The Doubling Farmers' Income Scheme is an ambitious initiative launched by the Government of India with the objective of improving the economic conditions of farmers and addressing the long-standing challenges in the agricultural sector (Kumar & Chahal, 2018). The scheme, which was announced by the Ministry of Agriculture and Farmers Welfare, aims to double farmers' income by 2022, with a focus on enhancing productivity, improving agricultural practices, and providing better market access.Agriculture remains the backbone of India's rural economy, employing more than half of the country's workforce (Sunder, 2018). However, despite its importance, farmers continue to face numerous hardships such as low income, inadequate infrastructure, poor market linkages, and high dependency on monsoons. These issues have contributed to a cycle of poverty in rural areas, which the Doubling Farmers' Income (DFI) initiative seeks to break.The strategy to achieve this goal involves a multi-pronged approach that includes improving farm productivity through the adoption of modern techniques, providing better credit access, promoting sustainable farming practices, enhancing irrigation facilities, reducing input costs, and fostering better price realization for produce. Additionally, the scheme also emphasizes the need for strengthening rural infrastructure, providing farmers with crop insurance, and increasing the coverage of government schemes (Kumar and Naik, 2021).By addressing both the supply-side and demand-side challenges, the Doubling Farmers' Income Scheme aims to ensure that farmers not only see a rise in their earnings but also experience an overall improvement in their quality of life (Press Release:Press Information Bureau, 2020). The success of this initiative is critical to India's broader economic growth and rural development, as well as to ensuring food security for its large and diverse population. Therefore, IARI Regional Station, Kalimpong tried to promote and demonstrate different advance farm technologies for doubling the production and income of farming communities in the region. The present article will discuss the few success stories on doubling farmers income under its intervention.

Success Story I

Like many other farmers in the village, Mr. Ajit Sarkar, a farmer from Bangkandi, Maynaguri, Jalpaiguri of West Bengal was engaged in traditional farming and living a simple farming life with his family. In his 5-acre land, he used to grow paddy, jute, cabbage, cauliflower and reared 5 local breeds of cows. Earlier from his 3 acre area he could get 45 q paddy with a net income of Rs.35000 and 10 q jute with a net income of Rs. 20000 from 1 acre area. He managed to earn an additional Rs.30000 by cultivating cabbage in 0.5 acre area and Rs.35000 by cultivating cauliflower in another 0.5 acre area. Further, he earned approximately Rs.80000 by selling milk in the local market. Thus, his annual net income was around Rs. 200000. But he was not satisfied with his current income from farming through which he hardly can support his family's needs and future aspiration for children's education. He always wanted to support his family through some additional income. Hence, he participated in demonstration program of improved paddy variety (PS-5, Pusa 1612,Swarna sub I, Pusa 1509), mustard (PM26, PM-30), JRO 204 variety of Jute, tomato (Pusa rohini), cow pea (Pusa Sukamal),cabbage (Rare ball F1), cauliflower (Pusa hybrid 2), green gram (Pusa Vishal), Arhar (Pusa 991) under IARI's DFI interventions. Ajit Sarkar was a quick learner and after attending IARI's project activities and training programme on DFI, he became confident in adopting new crops and improved varieties of paddy, cabbage, cauliflower, jute and cows. He also adopted different advanced cultivation practices like line sowing, zero tillage, mulching, raised bed cultivation etc. which helped him to enhance his production and yield under changing climatic conditions. After cultivation of new crops and varieties for five years, he was able to double his annual income from farming activities. He reported that now he was getting 60 q paddy from the same 3 acre area with an annual gross income of Rs.116000 and net income of Rs.80000 registering a 56.25 % increase in income. The jute production rose to 12 q with an annual gross income of Rs.55000 and net income of Rs.25000 (20% more than earlier). Similarly, the adoption of improved varieties of cabbage and cauliflower helped to raise the production to 75 q and 80 with 14.29 and 12.50 per cent increase in income respectively for each crop. With increase in income, the investment capacity of Mr. Ajit Sarkar raises, and he started dragon fruit cultivation in 0.2 acre area which was a new crop with high demand in the market of the region. He informed that approximately 10 q dragon fruit was harvested last year with a market value of Rs.150000 and net profit of Rs.80000. The production and income from the livestock sector have also increases significantly. Now he could harvest 50 l milk daily from 7 cows with an annual gross income of Rs.450000 and net income of Rs.200000. With hard work, zeal and determination, Mr. Ajit Sarkar's earnings have skyrocketed to approximately Rs.80,000 per month enabling him to become financially independent and having a better lifestyle for his family. Overall, his gross income in 2024 was Rs.9,26,000 and net income of Rs. 4,60,000 which is 263.04 per cent more than the base year income. He has developed the confidence to voice his opinion in farming and contribute in the decision-making process in his village and city. So, the story of Mr. Ajit Sarkar proved that income from agriculture can be doubled by adopting and applying modern cultivation technologies and practices.

Table 1: Increase in production and income under DFI intervention

Names	Benchmark (Baseline period 2018-19)				Post-intervention period (2022-23)				% increase over base year	
	Area (Acre)/ No.	Production (Q/Liter /No.)	Gross Income (Rs.)	Net Income (Rs.)	Area (Acre)/ No.	Production (Q/Liter /No.)	Gross Income	Net Income (Rs.)	Production (Q/Liter /No.)	Income
Paddy	3	45q	66000	35000	3	60q	116000	80000	25	56.25
Jute	1	10q	40000	20000	1	12q	55000	25000	16.67	20
Cabbage	0.5	70q	70000	30000	0.5	75q	75000	35000	6.67	14.29
Cauliflower	0.5	75q	75000	35000	0.5	80q	80000	40000	6.25	12.50
Dragonfruit	0	0	0	0	0.2	10q	150000	80000	100	100
Cow	5	30l/day	180000	80000	7	50l	450000	200000	40	60
Total	5/05	200/30	431000	200000	5.2/07	237/50	926000	460000	194.59	263.04

Fig 1: Field preparation for Line sowing of Jute

Fig. 2: Demonstration of Paddy variety (PS-5)

Success story II

This is the story of Bamon Rabha who is a small tribal farmer, aged 58,who lives in a small village namely*Khuklung Basti* in the Jalpaiguri district of West Bengal. The village is surrounded by deep forest on one side and a perennial river on the other side with records of frequent encroachment of wild animals in the house as well as cropland. This makes farming and livelihood highly difficult for them. Traditionally hewas farming different crops such as paddy in 2 acre area, mustard in 0.4 acre area, potato in 0.5 acre area and arecanut in 0.4 acre areawith an annual production of 24, 2.5, 90 and 4 quintals from the period of 2018-2019. He also had fivecows with aper day production of 30 liters milk. Before the intervention of DFI (Doubling Farmer Income), he had limited income from cultivating these crops and could not support his family. His net income from paddy, mustard, potato and arecanut cultivation was Rs. 15,000, Rs.4000, Rs. 45,000 and Rs. 80,000 respectively, whereas from milk production he used to earn Rs. 80,000. So, his overall annual net income was just Rs. 2,24,000 per year. Although he wanted to do his best to increase his overall income but he was clueless about how to achieve this. He had limited technological options, knowledge and skills to counter the problems oflow productivity, low quality seed, managing heavy pests and diseaseincidences in his farming activities. In this situation IARI makes diverse technological and extension interventions to enhance the yield and income of farming communities in the region (SEA_Kalimpong-08122015.pdf). The major technologies demonstrated were- Pusa 44, PS-5, PS-1850 and Pusa 1612 variety of paddy, PM-26, PM-28, PM-30 and Pusa Vijoy variety of mustard, JK Surabhi Gold variety of maize, JRO 204 variety of Jute, Sahiba, Sachi variety of carrot, KTS-I of broccoli, Pusa Shyamala of brinjal and CPCRI Mohitnagar cultivar of arecanut. Like many other farmers, Bamon Rabha too adopted IARI paddy varieties like PS-5, PS 1850, Pusa 44, mustard varieties PM-28, Arecanut cultivar of ICAR Mohitnagar and different improved vegetable varieties of IARI. After successful adoption and continuous cultivation of these improved varieties, he was able to enhance the yield and his income significantly within five year period. In the year 2022-2023, he increased his paddy cultivation area from 2 acres to 3 acres with production and income increases of 60%and 75 % respectively, mustard cultivation area was increased by 0.1 acre with 40 % increase in production and 60% rise in net income. In case of Potato cultivation, the area increased 8 times and production increased from 90 quintals to 240 quintals making it a 62.5 % upsurge, due to this the net income has also increased from 80.43 % with an amount of Rs. 2,30,000. The net income from Areca nut has surged from Rs. 80,000 to 1,50,000 in the area of 0.5 acre. From

ISSN : 2583-0910
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the livestock, he has gained a production of 30 liter to 50 liter of milk with an increase of 40% and a net income from 80,000 to 2,00,000. So, his net income has upsurged from Rs. 2,24,000 in 2018-2019 to Rs. 6,48,000 in 2022-2023 with a massive increase of 303.77percent, which is a remarkable journey. The overall data has been provided in Table 2.

Fig. 3: Input distribution under DFI

Fig. 4: Demonstration of Mustard variety-PM26

After the successful journey of 4 years, Bamon Rabha said that without the short duration Paddy Variety (PS-5), new improved variety of mustard (PM26, PM 28), healthy planting materials of Areca nut (ICAR-CPCRI cultivar) and improved livestock breed etc. provided by the IARI, he could not reach this milestone. From facing problems to becoming a high-income grower, has brought him immense pride, joy and satisfaction. With the help of DFI and his hard work, he also inspired the surrounding farmers to do farming with new advanced technologies and practices.

Table 2: Production and economics of major crops under DFI intervention

Names	Benchmark (Baseline period 2018-19)				Post-intervention period (2022-23)				% increase over base year	
	Area (Acre) / No.	Production (Q/Liter /No.)	Gross Income (Rs.)	Net Income (Rs.)	Area (Acre) / No.	Production (Q/Liter /No.)	Income	Net Income (Rs.)	Production (Q/Liter /No.)	Income
Paddy	2	24 q	40,000	15,000	3	60 q	100000	60000	60	75
Mustard	0.4	2.1 q	8750	4000	0.5	3.5 q	18000	10000	40	60
Potato	0.5	90 q	135,000	45,000	0.5	110 q	200000	70000	18.18	35.71
Areca nut	0.4	4 q	100000	80000	0.5	5 q	170000	150000	20	33.33
Cow	5	30 l	180000	80000	6	45 l	365000	160000	22.22	50
Total	3.3/5	120.1/30	463750	224000	4.5/6	178.5/45	853000	450000	160.40	254.04

Success story III

This is another success story of tribal empowerment through DFI from Khuklung Basti, District-Jalpaiguri, West Bengal. The farmer,Nipen Rabha,was also living in a forest village with limited livelihood opportunities. This 51 year old farmer has qualified higher secondary education and has a land holding size of 4.5 acres where he cultivated paddy, potato and arecanut and had 3 cows as livestock. Earlier, he used to produce 45 quintals of paddy, 180 quintals of potato, 4.5 quintals of arecanut and 15 liters of milk per day. He was able to make a gross income of Rs. 75,000, Rs. 2,70,000, Rs. 1,20,000 and Rs. 1,00,000 from paddy, potato, areca nut and livestock respectively with an annual gross income of Rs. 5,65,000 and net income of Rs. 2,70,000. He was hardly able to make a living with this low income from farming activities. He was thinking of leaving the farm activities for alternative livelihood opportunities and even thought of migrating to southern states like Kerala, Karnataka etc. to act as a labour. In this situation, IARI Regional station Kalimpong conducted CFLD programme on different improved varieties of major crops, like-paddy variety (PS-5, Pus 44, Pusa 1612,Swarna sub I, Pusa 1509), mustard (PM26, PM-28, PM-30, PM-31), Jute (JRO 204),Sponge gourd (Hybrid, JK-SHGH),Cucumber (ADV 268, Nalini-F1), Bottle gourd (Meghdoot, Vinayak F1), Chilli (LHC star, Megha), Snake gourd (Keerti_F1),Pumpkeen (Z-green, JK Madhul, NHPK/712-F1), tomato (Pusa rohini), cow pea (Pusa Sukamal),cabbage (Rare ball F1), cauliflower (Pusa hybrid 2), green gram (Pusa Vishal), Arhar (Pusa 991), arecanut seedlings of ICAR Mohitnagar cultivar, Guava(L-49/ Dudhekhaja, Baruipur, Allahabad safeda, red label), Litchi (Muzzafarpur, Elaichi, China, Shahi, Bombai).After the intervention of IARI, he adopted short duration Paddy Variety (PS-5),certified potato seed, arecanut seedlings of ICAR Mohitnagar cultivar, improved livestock breeds etc. During the survey, he said that now his production and income from farming have increased significantly. During this time, he increased his potato cultivation area from 1 acre to 2 acres and also increased the number of cow breeds from 3 to 5. With the new paddy variety, he was able to produce 60 q paddy from 3 acre area against 45 q in 2018 with the traditional variety. As a result, his gross income rose to Rs. 100000 and net income Rs.70000 from paddy cultivation (25% more than baseline condition). Similarly, in potato cultivation, he registered a 25% increase in production from 180 quintals to 250 quintals with an annual gross income of Rs. 5,00,000. In case of arecanut cultivation, his income rose to Rs. 1,75,000 from Rs. 120000 while production increased from 4.5 quintals to 7 quintals during 2018-2022. A massive jump in income has been noticed in milk production from livestock, where net income has surged by 72.52% with production increased from 15 liters to 40 liters making it a 62.50% increase. So, his total production has increased up to 151.21 percent with a gross income increment to Rs. 11,75,000 from Rs. 5,65,000 and net income increment from Rs. 2,70,000 to Rs. 6,50,000 respectively with an increase of 216.98 %. The overall data has been provided in Table 3.

Table 3: Production and economics of major crops under DFI intervention

Names	Benchmark (Baseline period 2018-19)				Post-intervention period (2022-23)				% increase over base year	
	Area (Acre) / No.	Production (Q/Liter /No.)	Gross Income (Rs.)	Net Income (Rs.)	Area (Acre) / No.	Production (Q/Liter /No.)	Income	Net Income (Rs.)	Production (Q/Liter /No.)	Income
Paddy	3	45 q	75,000	45,000	3	60 q	100000	70000	25	35.71
Potato	1	180 q	2,70,000	90,000	2	250 q	500000	250000	28	64
Areca nut	0.5	4.5	120000	90,000	0.5	7 q	175000	160000	35.71	43.75
Cow	3	15 l	100000	45000	5	40 l	400000	170000	62.50	73.52
Total	4.5/03	229.5/15	565000.00	270000.00	5.5/05	317/40	1175000	650000	151.21	216.98

Fig. 5 : Demonstration of paddy variety (Pusa 1612)

Fig.6: Areca nut seedling distribution

Conclusion

The case study on doubling farmer income showed that it is possible to double the farmers' income from farming activity by applying modern technologies and practices. The study showed that the yield of major crops like rice, jute and potato can be enhanced significantly by adopting high-yielding varieties. The same was true for vegetables like cabbage and cauliflower and plantation crops like arecanut. The study showed that the livestock sector also played an important role in doubling farmers' income. All these cases on doubling farmers income proved that modern agriculture is a profitable venture, and the young generation should be involved with full use of modern scientific tools and knowledge. These successful cases can attract more youth towards agriculture and address the problem of unemployment in the country.

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ISSN : 2583-0910
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Peer reviewed
monthly newsletter

Article ID : 04/XII/04/1224

A MINI REVIEW ON WINGED BEAN [*Psophocarpus tetragonolobus* (L.) DC.]

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Introduction

Psophocarpus tetragonolobus (L.) DC. commonly known as Winged bean, Asparagus pea or Goa bean is an underutilized tropical legume under the family of Fabaceace (Lepcha *et al.,* 2017; Sriwichai *et al.,* 2021) with a diploid genome (2n=2x=18) (Tanzi *et al.,* 2019). It is a highly nutritious vegetable with all parts of the plant being edible from the leaves, flowers, immature pods, seed and tuberous roots (Mohanty *et al.,* 2020). In terms of the nutritional composition of the seed, it is almost a duplicate of soybean as both the crops contain comparable proportion of protein, oil, minerals, vitamins and essential amino acids, and is also referred as 'soybean of the tropics' (Sriwichai *et al.,* 2022; Mohanty *et al.,* 2020). In tropical regions of the world where cultivation of soybean cultivation seem difficult, the crop can play a significant economic and ecological role (Lepcha *et al.,* 2017).

Origin and distribution

Psophocarpus tetragonolobus (L.) DC. is considered to have originated from South East Asia, owing to its long history of cultivation, however its progenitor is believed to be vanished. Another probable centre of origin is Papua New Guinea as the country has large genetic variation of the crop (Prasanth *et al.,* 2016; Bepary *et al.,* 2023). In the case of geographical distribution of the crop, India is the western most limits while Papua New Guinea constitutes the eastern most border. Thus the crop is grown in this range, in Sri Lanka, Bangladesh, Burma, Indonesia, Malaysia, Thailand, and the Philippines and also has been introduced to Madagascar and other African countries (Jarden, 1967; Hymowitz & Boyd, 1977; Lepcha *et al.,* 2017).

Botany: It is a dicotyledonous twining perennial herbaceous plant, however it is grown mostly as an annual (Tanzi *et al.,* 2019; Lepcha *et al.,* 2017). The plant can grow upto 3-5 m tall and has green trifoliate leaves. Flowers are borne singly or in threes in pseudo racemes with colour ranging from blue, bluish-white, purple or red. Pollen grains are unique within the genus and spheroidal in shape and size varies between 42.3–51.6 µm (polar axis) and 43.4–49.9 µm (equatorial axis). Pods are four sided with about 30-40 length and 3 cm width and bears about 5-21 seeds each pod. Green immature pods contain young seeds which can be consumed as a vegetable. Upon maturation and dehydration the pod transforms into wood containing edible seeds. The roots are tuberous and the size ranges between 8 and 12 cm in length and 2 to 4 cm in width. Its roots are tuberous; a tuber ranges in size between 2 to 4 cm in width and 8 and 12 cm in length (Poole, 1979; National Academy of Sciences, 1975; Venketeswaran, 1990; Prasanth *et al.,* 2016; Lepcha *et al.,* 2017).

Plant taxonomy (Bassal *et al.,* 2020)
Subkingdom: *Tracheobionta*
Super division: *Spermatophyta*

Division: *Mangoliophyta*
Class: *Mangoliopsyda*
Subclass: *Rosidea*
Order: *Fabales*
Family: *Fabaceae*
Subfamily: *Papilionoideae*
Tribe: *Phaseoleae*
Genus: *Psophocarpus*
Species: *tetragonolobus*

Fig. Winged bean

Food uses: Different indigenous groups of Asian and African countries have used winged bean for centuries as a minor food (Kantha *et al.,* 1984; Lepcha *et al.,* 2017). The whole plant is consumed from leaves, flowers, immature pods, seeds to tuberous roots (Mohanty *et al.,* 2020) and the young pods are the most commonly consumed part (Chankaew *et al.,* 2022). Immature pods are usually cooked and eaten directly or uncooked, raw young and tender pods are consumed as a salad. The leaves and stem tips are boiled, stir fried or eaten fresh. Flowers are utilized as a colorful garnish in salads or lightly boiled or fried. Seeds are eaten at both immature and fully matured stage an maybe prepared by soaking overnight, and are boiled, fried, roasted and parched or cook in different dish according to preferences. The seeds are used or making tempe and tofu as a substitute for soy beans. Tubers are boiled, fried baked or roasted and consumed (Ruberte and Martin, 1978; Thompson and Haryono, 1980).

Production

For cultivation of winged bean, hot and humid climate is ideal. It can live in a wide range of altitudes from 0 to 2000 m (Bassal *et al.,* 2020). The crop can withstand temperature ranging from 15.4 to 27.5°C and 700-4100 mm of annual rainfall (Duke, 1981). Although, above 25°C is favourable for vegetative growth and 20-25°C are suitable for flowering and fruiting. It can be grown in different type of soil from sandy to heavy clays, well-drained sandy loam, rich in organic matter having a pH of 4.3-7.5. Propagation is done mainly through seeds @15-20 kg/ha. Pre soaking of the hard seed coat for 1-2 days before sowing can be done. Germination occurs at 5-7 days after sowing. Spacing can be maintained at 90 cm x 90 cm for pods and 45 cm x 45 cm for seeds. For nutrient management, about 20 t/ha of FYM and fertilizer dose of N:P:K at 50:80:50

kg/ha is required. For obtaining good and quality yield, staking is an important cultural operation. For shoots and leaves harvesting, it can be done at tender stage. Harvesting for green pods can be done at 10 weeks after sowing and yield ranges from 5-10 t/ha. Tuberous root and seed yield is 5-10 t/ha and 1 to 1.5t/ha respectively (Tiwari *et al.,* 2023).

Conclusion

Legumes are commercially important crops, exploited for use as pulse, seed oil, fodder and processing of different food products. However, some legume crops such as winged beans are neglected. Despite its cultivation in some areas and region, it is not properly exploited. Different studies and trials are required for utilization to its full potential.

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ISSN : 2583-0910
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Article ID : 04/XII/05/1224

THE PHYSIOLOGY OF IRREGULAR FLOWERING IN MANGO-A BRIEF NOTE

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Abstract
The physiological and biochemical changes in terms of chlorophyll content, total sugar, reducing sugar, protein level, nitrate reductase enzyme activity, and biophysical attributes such as internal leaf temperature, internal relative humidity, diffusion resistance and rate of transpiration are the characters which are influenced during irregular bearing in mango. Apart from the gene expression and the protein which are expressed, can also be correlated with the help of studying the proteomics profiles, Proteomics, when combined with other complementary technologies such as molecular biology, has enormous potential to provide new insight into biology of irregular flowering. To understand the complex biological systems that in their entirety will ultimately provide answers that cannot be obtained from the study of individual proteins and can venture towards elucidating the exact causes and how to get benefited with irregular pattern of flowering of mango.

Introduction

Mango trees are polygamous bearing both perfect and hermaphroditic flowers, having both pistil and staminate structures. Both types of flowers are born in same inflorescence Mango inflorescence bears in terminal panicle & number of flowers in panicle may vary from 1000 to 6000 depending on the varieties. Panicles develop from dormant apical buds or lateral buds during floral induction. Mango flowers usually open during the night and early morning hours and the flowering duration is usually of short *i.e.* 2 to 3 weeks. The phenomenon of flowering in mango is very complex. Normally in one year (on year) it crops heavily but bear less crop or no crop in the following year (off year). In next year again it bears heavily. The rhythm of bearing in mango is not alternate strictly but irregular or erratic. According to research findings this phenomenon is mostly due to varietal as well as environmental factor. Night temperature < 19^0 C in combination with day temperature < 30^0 C typically induces flowering of mango tree. Choice varieties such as Alphonso, Imam Pasand, Mulgoa, Peter etc., are mostly erratic in bearing. In most of the studies FLOWERING LOCUS T-like gene (MiFT) was isolated from mango and characterized. The expression of MiFT was increased only in leaves under floral-inductive conditions. GA metabolism genes were also isolated from mango and the pattern of their expression was investigated. The final step of biosynthesis of active GA, and its gene expression surged only in heavy crop load trees under cool temperature which was controlled by Gibberelin-3- oxidase (GA_3-ox).

Factors influencing irregular bearing

Environmental factor

The developmental fate of mango buds is strongly influenced by temperature prevails in that location. Cool night temperature < 19^0 C in combination with day temperature < 30^0C typically induces flowering of mango tree. Bangerth *et al*. (2004) climactic factors might be due to major phytohormone levels in leaves and shoots of mango trees. Transfer from a warm, vegetatively inductive condition to a cool, floral inductive environment at early bud break results in formation of Vegetative / Floral transition shoots. Transfer from cool to warm conditions at the same stage of bud break results in formation of Floral / Vegetative transition shoots. The flowering response to temperature occurs in mango growing in subtropical latitudes, where cool temperature is the dominant induction factor. Many cultivars flowering erratically in low latitude tropics, providing continuously warm temperature with high soil and atmospheric moisture conditions. Under such conditions, the age of stems is the dominant inductive factor and occasional cool night temperatures in the upper latitude tropics have a positive moderating effect.

Florigenic promoter

Florigenic prometer induces flowering. It is synthesized in mango leaves which is governed by temperature. FP is translocated through phloem to apical buds. Florigenic promoter is mainly responsible for flower induction. The vegetative promoter (V_P) also induces flowering. High ratio of F_P/V_P favours floral induction, low FP/VP favours vegetative growth and intermediate ratios favours mixed shoots. Florigenic promoter is up regulated on exposure to cool temperature (<18˚C) in sub-tropical conditions. In tropics, regardless of temperature floral induction occurs in terminal stems that have attained sufficient time to rest of at least 4-5 months depending up to cultivar (Davenport et al., 2011).

Number of leaves

Presence of leaves is necessary for flower bud differentiation in mango. Flower inducing compounds supplied by leaves, and some hormone similar to the hypothetical florigen. According to Davenport, 2007 site of florigenic promoter's synthesis is leaves. For flower induction mango requires 45-50 leaves.

Role of carbohydrates

Increase in carbohydrate availability is important attribute to floral initiation in mango. The C: N ratio differed with growth of shoots in the varieties, which reveals its dependence upon environmental conditions and prevailing metabolic balance. The positive association of floral bud initiation with C:N ratio shows that the increase in carbohydrate availability and translocation is vital to the floral initiation in mango. Thus, shoots with higher carbohydrate content are expected to favour flower initiation. For this a critical level of carbohydrate is desired to express flowering favourable activity. As reproductive growth is a high energy requiring developmental event, there is requirement of high carbohydrate demand at flowering (Singh, 1978).

Gene expression

Recent advances in molecular biology of flowering in the facultative, long-day, model herbaceous plant, *Arabidopsis thaliana* has provided new insights into the nature of the floral stimulus. Activation of the ***CONSTANS*** *(CO)* gene encodes a protein, which in turn induces expression of the ***FLOWERING LOCUS T*** *(FT)* gene localized in phloem tissue in vascular veins of leaves (Lopez and Runkle, 2005). The protein product of FT acts as the florigenic component that is translocated to *Arabidopsis* buds. This complex phenomenon could be solved by genomic and transcriptome tools. This helps in understanding metabolic and molecular processes involved in floral biology. Transcriptomics analysis has resulted into numerous differentially expressed genes, which allows identification of mechanism that can change "on" into "off" buds. Understanding the cellular and molecular mechanisms assists in the development of flowering. Generated information can be utilized for identification of potential parents and desirable hybrids.

Hormonal effect

Mango flowering involves hormonal regulation of shoot initiation and induction events resulting in reproductive shoot formation. A balance or ratio of endogenously regulated phytohormones, thought to be auxins from leaves and cytokinins from roots, appears to govern the initiation cycle independently from inductive influences. Induction of reproductive or vegetative shoots is thought to be governed by the ratio of a temperature-regulated florigenic promoter. Increase in total phenols, soluble protein, total chlorophyll content and the decreases in IAA oxidase and increase gibberellic acid which leads to induction of flowering. Increase in total phenol, might be due to the excess production of hydrogen peroxide by increased respiration or due to the activation of hexose mono phosphate (HMP) shunt pathway, acetate pathway and release of bound total phenols by hydrolytic enzymes. The depletion in sugar level found to be is also responsible for the accumulation of total phenols since the sugars are utilized for the synthesis of total phenols. The total phenol exhibited highest levels during flower bud differentiation (Chandler, 1950).

Summary

The bearing rhythm of mango is not alternate strictly but irregular or erratic. This phenomenon has been attributed to be caused by genetical, physiological, environmental and nutritional factors. In most of the studies FLOWERING LOCUS T- like gene (MiFT) and gibberellins metabolism genes have been reported, isolated and characterized. Many hormones have also been isolated to be involved in these unique phenomena of offseason flowering like auxins from leaf and cytokinins from root. Since mango bear fruits on previous year shoot so pruning should not be severe. Light pruning activates quiescent fruit bearing buds by redistributing endogenous hormonal substances and ultimately favors flowering. After harvesting branches should be trooped off to open the centre. Other than this spray of 1 % potassium nitrate or 1 % potassium dihydrogen phosphate + 1 % urea thrice at monthly interval or soil treatment with paclobutrazol during September - October months should also be followed to achieve balance in carbon: nitrogen ratio. The treated trees will give bumper crop.

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ISSN : 2583-0910
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Peer reviewed
monthly newsletter

Article ID : 04/XII/06/1224

BIO LEATHER USING SEAWEEDS: A SUSTAINABLE REVOLUTION IN MATERIAL SCIENCE

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Abstract

The increasing demand for eco-friendly and sustainable alternatives to conventional leather has spurred significant interest in bio-based materials. One such innovation is the development of bio leather using seaweed, which not only addresses environmental concerns but also presents unique properties and advantages over traditional materials. This article explores the various aspects of bio-leather production from seaweed, including its sources, extraction methods, production processes, properties, and potential applications. The use of seaweed as a raw material for bio leather aligns with sustainable development goals by minimizing environmental impact, reducing reliance on animal and synthetic products, and contributing to the circular economy.

Introduction

The traditional leather industry is associated with several environmental issues, such as deforestation, water pollution, and high greenhouse gas emissions. The tanning process, which involves the use of toxic chemicals like chromium salts, poses severe health risks to workers and causes detrimental effects on the surrounding ecosystems. With the rising awareness of these environmental and ethical concerns, researchers and industries are focusing on finding alternatives that are not only sustainable but also comparable in performance and aesthetics to conventional leather.

Bio leather, derived from various organic sources such as fungi, bacteria, and plants, has emerged as a promising material in this context. Among these sources, seaweeds have garnered attention due to their rapid growth, high biomass yield, and ability to sequester carbon dioxide. Seaweed-derived bio leather offers a unique combination of mechanical properties, biodegradability, and environmental benefits, making it an ideal candidate for sustainable material development.

Seaweed as a raw material for bio leather

Seaweed, or macroalgae, is a diverse group of marine plants found in oceans, seas, and coastal regions. It is categorized into three main types based on pigmentation: brown algae (Phaeophyceae), red algae (Rhodophyta), and green algae (Chlorophyta). Each type possesses distinct biochemical compositions, including polysaccharides (such as alginates, carrageenan, and agar), proteins, fibers, and bioactive compounds, making them suitable for various industrial applications.

The use of seaweed for bio-leather production capitalizes on its sustainable properties:

Renewability and rapid growth: Seaweeds grow much faster than terrestrial plants, with some species doubling their biomass in just a few days.

Carbon sequestration: Seaweed cultivation captures and stores significant amounts of CO_2, helping mitigate climate change.

No land and freshwater requirement: Unlike traditional crops, seaweeds do not compete for arable land or freshwater resources, thereby reducing the burden on agricultural systems.

Waste utilization: Seaweed farming can be integrated with marine aquaculture systems, utilizing waste nutrients and promoting a circular approach.

Bio leather production process from seaweed

The production of bio leather using seaweed involves multiple stages, each crucial for achieving the desired properties of the final product. The basic process includes extraction, modification, casting, and finishing:

Seaweed extraction:

- Seaweed is harvested, washed, and dried to remove impurities such as sand and salts.
- The dried seaweed is then processed to extract key polysaccharides (e.g., alginate, carrageenan, or agar) using chemical or enzymatic methods.
- This extraction step typically involves boiling the seaweed in an alkaline or acidic solution, followed by filtration and precipitation to obtain a purified polysaccharide solution.

Modification and blending:

The extracted polysaccharides are modified to improve their mechanical properties and compatibility for leather-like applications. Crosslinking agents, plasticizers, and other additives can be introduced to enhance flexibility, strength, and water resistance.

The seaweed extract can also be blended with other natural polymers such as cellulose, chitosan, or proteins to achieve a more leather-like texture and feel.

Casting and film formation:

The modified seaweed solution is cast into Molds or spread evenly on flat surfaces to form thin films. These films are allowed to dry under controlled conditions to prevent cracking and to ensure uniform thickness.

The resulting films can be further processed through rolling, pressing, or embossing to impart textures and surface patterns.

Tanning and finishing:

Although traditional tanning methods are not used, bio leather from seaweed can undergo tanning-like processes using eco-friendly agents such as plant-derived tannins or enzymatic treatments.

The final material is then finished with natural oils, waxes, or coatings to improve durability, water resistance, and aesthetic appeal.

Properties and advantages of seaweed bio leather

Bio leather derived from seaweed exhibits several desirable properties, making it a potential substitute for traditional leather:

Mechanical properties:

Seaweed bio leather can be engineered to achieve a wide range of tensile strengths and elongation properties by varying the composition and processing conditions.

The addition of crosslinkers and plasticizers enhances flexibility and tear resistance.

Biodegradability:

Seaweed-based bioleather is fully biodegradable and compostable, leaving no harmful residues in the environment at the end of its life cycle.

Water resistance and breathability:
The polysaccharide-rich composition imparts natural water resistance and breathability to the material, making it suitable for apparel and accessories.

Non-toxic and hypoallergenic:
The absence of synthetic chemicals and heavy metals in the production process ensures that the material is non-toxic and hypoallergenic, making it ideal for consumer goods.

Aesthetic versatility:
Seaweed bio leather can be dyed, textured, and embossed to mimic the appearance and feel of conventional leather, offering a wide range of design possibilities.

Potential applications of seaweed bio leather
The unique properties of seaweed bio leather make it suitable for various applications across industries:

Fashion and apparel: Jackets, shoes, bags, and accessories.
Upholstery: Furniture coverings, car interiors, and decorative panels.
Packaging: Sustainable packaging materials for luxury goods and electronics.
Industrial uses: Protective coverings, insulation materials, and eco-friendly coatings.

Challenges and future directions
Despite its potential, the commercialization of seaweed bio leather faces several challenges:

Scalability and cost:
Scaling up production while maintaining consistent quality is a major challenge. The cost of raw materials and processing needs to be optimized for competitive pricing.

Material performance:
Improving the durability, abrasion resistance, and longevity of seaweed bio-leather is crucial for its adoption in mainstream applications.

Consumer acceptance:
Educating consumers about the benefits and properties of seaweed bio-leather is essential for driving demand and acceptance.

Future research should focus on optimizing production methods, exploring novel seaweed species, and enhancing the functional properties of bioleather. Integration with other bio-based materials and technologies can further expand the potential applications of seaweed bio-leather in the sustainable materials industry.

Conclusion
The development of bio leather using seaweeds represents a promising step towards sustainable material innovation. With its unique properties, environmental benefits, and wide range of applications, seaweed bioleather has the potential to revolutionize industries traditionally reliant on conventional leather. Continued research and technological advancements will be key to overcoming current limitations and unlocking the full potential of seaweed-based materials. By embracing such innovations, we can move closer to a sustainable and circular economy, reducing our impact on the planet and fostering a greener future.

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Article ID : 04/XII/07/1224

AI IN AGRICULTURE

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Introduction

The growth of the global population, which is projected to reach 10 billion by 2050, is placing significant pressure on the agricultural sector to increase crop production and maximize yields. Pushed by many obstacles to achieving desired farming productivity like limited land holdings, labour shortages, climate change, environmental issues, and diminishing soil fertility, to name a few, the modern agricultural landscape is evolving, branching out in various innovative directions. To address looming food shortages, two potential approaches have emerged: expanding land use and adopting large-scale farming, or embracing innovative practices and leveraging technological advancements to enhance productivity on existing farmland. AI is becoming more prevalent day by day in agriculture, and AI-based devices are elevating the current farming system. Agriculture is dependent on a number of variables, including soil nutrient content, moisture, crop rotation, rainfall, temperature, etc. and products based on artificial intelligence can use these variables to track crop productivity. Applications that use AI in agriculture have been created to assist farmers in precise and regulated farming by giving them the right advice on water management, crop rotation, timely harvesting, the type of crop to be cultivated, optimal planting, pest attacks, and nutrition management. The integration of AI in agriculture is paving the way for smarter, more sustainable farming practices that can meet the growing global food demand.

Benefits of AI in agriculture

Agriculture has been the backbone of human civilization for millennia, providing sustenance as well as contributing to economic development. In recent years, the world has witnessed rapid advancements in agricultural technology, revolutionizing farming practices. These innovations are becoming increasingly essential as global challenges such as climate change, population growth together with resource scarcity threaten the sustainability of our food system. Therefore, introducing AI solves many challenges and helps to diminish many disadvantages of traditional farming. The integration of AI in agriculture not only boosts productivity and profitability but also contributes to a more sustainable and resilient food system.

The benefits of AI in agriculture are numerous and impactful, enhancing various aspects of farming. Here are some key advantages:

- ✓ **Increased efficiency**: AI optimizes resource use, leading to more efficient planting, irrigation, and harvesting processes, ultimately saving time and labour.
- ✓ **Data-driven decisions**: Access to real-time data and predictive analytics empowers farmers to make informed decisions based on comprehensive insights.
- ✓ **Higher yields**: By analyzing data on weather, soil health, and crop performance, AI helps farmers maximize their yields through informed decision-making.
- ✓ **Disease and pest detection**: AI can quickly identify signs of disease or pest infestations, allowing for early intervention and minimizing crop loss.

- ✓ **Cost savings**: Improved resource management reduces input costs, such as water, fertilizers, and pesticides, leading to better profitability.
- ✓ **Labour management**: Automation and AI-powered machinery reduce the dependency on manual labour, helping address labour shortages in the agricultural sector.
- ✓ **Market insights**: AI analyzes market trends and consumer behaviour, helping farmers make better decisions about crop selection and marketing strategies.

Areas of using AI in agriculture

AI is being utilized in various areas of agriculture, leading to improved efficiency and productivity. Here are some key areas:

- **Weather forecasting using AI:** With the aid of artificial intelligence, farmers can analyze weather conditions by using weather forecasting, which helps them to plan the type of crop that can be grown and when seeds should be sown.
- **Soil and crop health monitoring system:** Integrating sensors and AI systems enables farmers to accurately monitor how much water and nutrients are available in the soil. Using sensors in soil monitoring could involve deploying devices that measure various parameters like soil moisture, temperature, pH levels, and nutrient content. These sensors send information back to AI systems which then analyze it and provide instructions to farmers. For example, the AI system might identify areas of the field where the soil is too dry or too moist and provide recommendations on when and how much water to apply to optimize crop growth.
- **Protecting crops:** AI can monitor the state of plants to spot and predict diseases, identify and remove weeds, and recommend effective treatment of pests. For example, a precision agriculture startup called Taranis uses computer vision and machine learning to analyze high-resolution images of crops, providing plant insights to identify signs of stress or disease. Their AI-powered technologies can detect and classify diseases and pests with high accuracy.
- **Observing crop maturity:** Estimating crop growth and maturity is a tedious and challenging task for farmers, but AI can handle the job quickly and precisely. Through AI-powered hardware such as sensors and image recognition tools, farmers can detect and track crop changes to obtain accurate predictions on when crops will reach optimal maturity. Studies have found that using AI to predict the maturity of crops resulted in a higher accuracy rate than the accuracy rate achieved by human observers.
- **Intelligent spraying:** Weed or pest control can be automated with AI technologies. With the help of computer vision, weeding robotics is said to be remarkably precise, resulting in a 90% reduction in pesticide usage. Based on data analytics, these tools can calculate how much pesticide is needed for each field based on data about its history, soil status, or crop type. Blue River Technology has disrupted traditional weed control methods with its flagship product, the "See and Spray" machine. Using computer vision and machine learning, the device can distinguish between crops and weeds and then apply herbicide only where needed. This can be cost-effective.
- **Breeding seeds:** By collecting data on plant growth, AI can help produce crops that are less prone to disease and better adapted to weather conditions. With the help of AI, scientists can identify the best-performing plant varieties and crossbreed them to create even better hybrids. gathering genomic information of seeds through AI technologies like that of Seed-X can help to speed up the process and increase the likelihood of success.

- **Analyzing market demand:** Analyzing market demand is a crucial aspect of modern agriculture. AI can help farmers select the best crop to grow or sell. Descartes Labs is a new Mexico-based company that offers an AI-powered platform to help farmers evaluate market demand. The company develops machine learning algorithms to analyze satellite imagery and weather data, providing valuable insights on optimal planting times and the best crops to grow.

Future of AI in Agriculture

Artificial Intelligence (AI) in agriculture is poised to grow significantly in the coming years, as it has the potential to revolutionize the sector by improving crop yields, reducing waste, and increasing efficiency. According to a report by MarketsandMarkets, the AI in agriculture market is predicted to experience explosive growth, with the market size expected to grow from $2.35 billion in 2020 to $10.83 billion by 2025 at a Compound Annual Growth Rate (CAGR) of 35.6% during the forecast period. Collecting and analyzing large amounts of data is among the most notable advantages of AI in agriculture for farmers. This will lead to more informed decision-making and improved crop yields, essential for addressing the global food security challenge. While the benefits of AI in agriculture are numerous, the reality is that most farmers worldwide, particularly smallholder farmers, lack the necessary resources to implement these technologies. Smallholder farmers typically have limited access to technical training, which makes it difficult for them to operate AI systems effectively. Many also lack the financial resources needed to purchase the equipment and software required for AI-based farming.

The adoption of AI in agriculture must be inclusive, considering the needs and limitations of smallholder farmers, who make up a significant portion of the global agricultural workforce. Initiatives that provide access to training and funding for smallholder farmers to implement AI-based farming practices can help bridge the divide. With this, farmers at all levels can benefit from emerging technologies that the world needs to secure our food system's future.

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Article ID : 04/XII/08/1224

BIOFORTIFICATION OF FRUITS AND VEGETABLES: A SUSTAINABLE PATH TO NUTRITION SECURITY IN INDIA

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Introduction

India faces a dual burden of malnutrition, characterized by the coexistence of undernutrition and overnutrition. Despite significant strides in food production, the country struggles with nutritional deficiencies, especially among vulnerable populations like children and women. Micronutrient deficiencies—commonly known as "hidden hunger"—affect over two billion people globally, including a substantial portion of India's population. Biofortification of fruits and vegetables emerges as a promising, cost-effective, and sustainable strategy to address these deficiencies and enhance nutrition security.

Biofortification is the process of increasing the nutritional content of crops through agricultural practices, conventional breeding, or modern biotechnology. Unlike fortification, which involves adding nutrients during food processing, biofortification integrates nutrients directly into the plant. This article explores the role of biofortified fruits and vegetables in improving India's nutrition security, discusses ongoing initiatives, and highlights challenges and future directions.

The Need for Biofortification in India

Prevalence of Micronutrient Deficiencies

India's high burden of micronutrient deficiencies stems from diets predominantly based on cereals, which lack sufficient vitamins and minerals. Common deficiencies include:

1. **Iron deficiency**: Leading to anemia, especially in women and children.
2. **Vitamin A deficiency**: A significant cause of preventable blindness in children and increased risk of mortality.
3. **Zinc deficiency**: Impairs immunity and increases susceptibility to infections.

Role of Fruits and Vegetables in Diet

Fruits and vegetables are nutrient-dense and can provide essential vitamins, minerals, fiber, and phyto chemicals. The World Health Organization (WHO) recommends eating at least 400 grams of fruits and vegetables per day. However, their consumption in India is often below the recommended dietary allowance (RDA), particularly in rural and economically disadvantaged populations. Biofortification of these crops offers a dual advantage—improving their nutritional profile while promoting their cultivation and consumption.

Mechanisms and Methods of Biofortification

1. **Conventional Breeding :** Plant breeders select and cross varieties with high nutrient content to produce biofortified crops. For example, orange-fleshed sweet potatoes (rich in β-carotene) were developed through traditional breeding methods.
2. **Agronomic Practices :** This involves applying nutrient-rich fertilizers to enhance the mineral content of crops. For instance, zinc-enriched fertilizers can increase zinc content in leafy vegetables.
3. **Genetic Engineering :** Genetic modification allows the introduction of specific genes to boost nutrient levels in crops. Golden rice, enriched with pro-vitamin A, is a well-known example of this approach.

Key Biofortified Fruits and Vegetables in India

India has started integrating biofortified varieties into its agricultural system. Some notable examples include:

1. **Iron- and Zinc-Enriched Potatoes :** Developed using conventional breeding, these potatoes help combat iron and zinc deficiencies while being a staple food in Indian households.
2. **β-Carotene-Enriched Sweet Potatoes :** The orange-fleshed sweet potato (OFSP) contains high levels of β-carotene, a precursor to vitamin A. Its consumption addresses vitamin A deficiency, particularly in children.
3. **Iron-Enriched Spinach :** Iron biofortification of leafy greens like spinach has gained momentum to combat anemia in India.
4. **Vitamin C-Enriched Citrus Fruits :** Enhanced vitamin C content in lemons and oranges can bolster immunity and combat oxidative stress.
5. **Anthocyanin-Enriched Tomatoes :** These biofortified tomatoes contain higher levels of antioxidants, which help in reducing the risk of chronic diseases.

Some examples of Biofortified crops in India

India has made significant progress in developing and promoting biofortified crops to combat micronutrient deficiencies. Here are some notable examples of biofortified crops cultivated in the country:

1. Zinc-Enriched Wheat

- **Nutrient Targeted**: Zinc
- **Key Variety**: WB02
- **Significance**: Zinc-enriched wheat addresses zinc deficiency, which is critical for immunity and child growth. It has been introduced in several states, including Uttar Pradesh and Bihar.

2. Iron-Rich Pearl Millet

- **Nutrient Targeted**: Iron
- **Key Variety**: Dhanashakti
- **Significance**: This variety contains 70–75% more iron than conventional pearl millet and is widely grown in semi-arid regions.

3. Vitamin A-Enriched Sweet Potato

- **Nutrient Targeted**: β-Carotene (precursor to Vitamin A)
- **Key Variety**: Orange-Fleshed Sweet Potato (OFSP)

- **Significance**: Helps combat vitamin A deficiency, particularly in children and pregnant women. It is being promoted in Odisha, where vitamin A deficiency is prevalent.

4. Protein-Rich Maize

- **Nutrient Targeted**: Lysine and Tryptophan (essential amino acids)
- **Key Variety**: Quality Protein Maize (QPM)
- **Significance**: QPM varieties like Shakti-1 improve protein quality, benefitting populations relying on maize as a staple.

5. Iron-Enriched Lentils

- **Nutrient Targeted**: Iron
- **Key Variety**: Pusa 16
- **Significance**: Lentils enriched with iron can reduce anemia in women and children while providing protein-rich diets.

6. High-Iron Rice

- **Nutrient Targeted**: Iron
- **Key Variety**: DRR Dhan 45
- **Significance**: Iron-rich rice varieties are being developed to address widespread iron-deficiency anemia in rice-consuming populations.

7. Zinc-Enriched Rice

- **Nutrient Targeted**: Zinc
- **Key Variety**: DRR Dhan 48
- **Significance**: This variety is promoted in states like West Bengal and Odisha to tackle zinc deficiency.

8. Biofortified Mustard

- **Nutrient Targeted**: Selenium
- **Key Variety**: Pusa Mustard 30
- **Significance**: Enriched mustard varieties enhance selenium intake, which supports antioxidant defenses.

9. Anthocyanin-Rich Colored Wheat

- **Nutrient Targeted**: Anthocyanins (antioxidants)
- **Key Variety**: Developed by ICAR
- **Significance**: The colored wheat varieties provide antioxidants that reduce the risk of chronic diseases.

10. Iron-Enriched Bananas (Under Development)

- **Nutrient Targeted**: Iron
- **Significance**: Biofortified bananas are being researched in collaboration with global organizations to address iron deficiency.

Current Initiatives and Success Stories in India

1. **Harvest Plus Program :** Harvest Plus, part of the CGIAR research program, works extensively in developing and promoting biofortified crops in India. Their efforts include the development of iron-rich pearl millet and zinc-enriched wheat.

2. **Indian Council of Agricultural Research (ICAR) :** ICAR has been instrumental in developing biofortified varieties of staple crops and vegetables. Examples include protein-rich maize and high-iron lentils.
3. **State-Level Interventions :** States like Odisha and Uttar Pradesh have integrated biofortified crops into public distribution systems and mid-day meal schemes, ensuring that biofortified food reaches schoolchildren and low-income families.
4. **Collaborations with Private Sector and NGOs :** Partnerships between agricultural universities, private companies, and non-governmental organizations have accelerated the research and distribution of biofortified crops.

Benefits of Biofortified Fruits and Vegetables

1. **Improved Public Health :** Regular consumption of biofortified crops can significantly reduce the prevalence of micronutrient deficiencies, improving overall health outcomes.
2. **Cost-Effectiveness :** Unlike pharmaceutical supplements, biofortification offers a one-time investment with long-term benefits, making it a cost-effective solution for nutrition security.
3. **Sustainability :** Biofortification aligns with sustainable agriculture practices, as nutrient-dense crops can improve soil health and reduce the need for chemical fertilizers.
4. **Economic Empowerment :**Cultivation of biofortified crops can enhance farmers' incomes by catering to health-conscious consumers willing to pay a premium for nutrient-rich produce.

Challenges in Scaling Biofortification

1. **Lack of Awareness :** Many farmers and consumers are unaware of the benefits of biofortified crops, leading to low adoption rates.
2. **Regulatory Hurdles :** Approvals for genetically modified biofortified crops face strict regulations and public skepticism.
3. **Market Accessibility :** The absence of dedicated markets and supply chains for biofortified crops limits their availability to consumers.
4. **Cultural Barriers :** In India, food preferences and cultural practices can influence acceptance, particularly for crops with altered appearances or flavors.
5. **Climate Change Impacts :** Climate variability can affect the yield and nutrient content of biofortified crops, posing a challenge to their widespread adoption.

Future Directions for Biofortification in India

1. **Integration into Policies :** Incorporating biofortified crops into national nutrition programs, such as the Integrated Child Development Services (ICDS) and Public Distribution System (PDS), can significantly enhance their reach and impact.
2. **Research and Development :** Increased investment in agricultural research is needed to develop climate-resilient and nutritionally superior biofortified varieties.
3. **Public Awareness Campaigns :** Large-scale awareness initiatives can educate farmers, consumers, and policymakers about the benefits of biofortification.
4. **Strengthening Supply Chains :** Building robust supply chains for biofortified crops will ensure their availability and affordability for consumers across socio-economic strata.
5. **International Collaboration :** Collaborations with global organizations and knowledge-sharing with countries that have successfully implemented biofortification strategies can accelerate India's progress.

Conclusion

Biofortification of fruits and vegetables holds immense potential to transform India's nutrition landscape. By integrating biofortified crops into agricultural practices and public health programs, India can address the challenge of hidden hunger sustainably and cost-effectively. While there are hurdles to overcome, concerted efforts from the government, research institutions, private sector, and civil society can make biofortification a cornerstone of nutrition security.

Through continued innovation and collaboration, biofortified fruits and vegetables can not only improve the health of millions but also contribute to a more resilient and nutritionally secure India.

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/09/1224

CULTIVATION OF BUCKWHEAT (*Fagopyrum esculentum*)

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Introduction

Buckwheat is an annual herbaceous plant. Buckwheat (*Fagopyrum esculentum*) is a pseudo cereal, belongs to the family *Polygonaceae*, one of the major traditional, underexploited crop having good nutritional value, can be grown in poor agroclimatic regions and requires low inputs for its cultivation (Verma, 2018). The common buckwheat is originated in central and western china. Buckwheat locally known as *dyat, dro, bro, fafar*, etc is grown traditionally in Jammu and Kashmir. Buckwheat is a plant cultivated for its grain like seeds so that it is referred as a pseudocereal. and it is derived from the anglo-saxon word boc (beech) and whoet (wheat) because the word beech was used since the fruit of the plant was similar to the beechnut.

Buckwheat is among the various ancient cultivated crops of Asia and is mainly cultivated in India, China, Nepal, Canada, North Korea, Bhutan, Eastern Russia, Mongolia and Japan. However, in the first half of 20th Century, the production of Buckwheat has declined. Buckwheat production in the world in 2018 was 2.9 million tones which have been declining when compared over the past three years.

India, Buckwheat is grown majorly in hill areas of Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Chattisgarh, Uttar Pradesh, West Bengal, Upper Assam region, Sikkim, Meghalaya, Manipur, Arunachal Pradesh, Nilgiris and Palani hills of Tamil Nadu, and Kerala. There is a decline in the cultivation and production of Buckwheat due to changing patterns of land use in India.

In India, there are twenty species of Buckwheat cultivated across various hilly regions, out of these only nine species have desirable nutritional value and two are commonly grown. The commonly grown and consumed buckwheat species are Fagopyrum esculentum Moench (Common buckwheat) and Fagopyrum tataricum (Tartary buckwheat). In Asia, Tartary buckwheat is widely grown whereas Common Buckwheat grows widely in Unites States, Europe and Asia. In India, both the common buckwheat and Tartary buckwheat are grown in different levels of altitude, common buckwheat in lower altitudes upto 1000 m and the other in higher altitudes >2500 m^2.

Buckwheat is one of the pseudocereals and minor cereals grown annually in hilly regions of India. Pseudocereals are not true cereals. Botanically cereals are monocotyledonous plants, whereas pseudocereals are dicotyledonous. Buckwheat is adaptable to extreme cold, lack of water, less soil fertility and varying climatic conditions. Buckwheat needs at least 100 mm rainfall to grow. Buckwheat plant shows C4 metabolism as well as shallow taproot and secondary roots that can spread up to 1 meter deep. Flowers are small regular and can be white and pink in colour. Seeds are triangular in shape and have a dark brown and black in colour.

Buckwheat is a nutrient dense, gluten-free plant source with abundant health benefits owing to the higher presence of various bioactive components of buckwheat, such as flavonoids, polyphenols, polysaccharides, saponins, proteins, fatty acids, and trace elements.The main consumption buckwheat form is seed. It is a rich source of starch and contains many valuable compounds, such as proteins, antioxidative substances, trace elements and dietary fibre. Whole buckwheat contain 55% starch, 12% protein, 4% lipid, 2% soluble carbohydrates, 7% total dietary fibre, 2% ash and 18% other components (organic acids, phenolic compounds, tannins, phosphorilated sugars, nucleotides and nucleic acids). Buckwheat also contains rare elements such as K, Mg, P, Fe, Ca, Cu, Zn, Se, Ba and B, I, Pt, Co. The primary antioxidants in buckwheat are rutin, quercetin and hyperin.

Due to the presence of bioactive compounds, buckwheat has engrossed the attention of researchers owing to its healing and functional food properties. It has significantly proven to be anti-oxidative, anti-cancer, hepatoprotective, anti-hypertension, anti-tumor, anti- inflammatory, anti-diabetic, neuro-protection, cholesterol-lowering, and so on (Nazir *et al.,* 2021). The flour of buckwheat is used in the preparation of breads for breakfast, in pancakes, and porridges in most of the areas of Ladakh region. A popular food item made of buckwheat flour in Kargil is known as kiseer or giziri, which is similar to plain dosa. Buckwheat flour is mixed with wheat and barley flour to produce nodules and biscuits. The whole grains of buckwheat when poped and soften are highly platable and are as good as those prepared from the corn or other millets. In several remote areas of Ladakh people prepare a dye from hulls of buckwheat and use it in textile fabrics. Buckwheat is also used for livestock and poultry as forage and feed, (Ahmad *et al.*, 2019).

Buckwheat is a pseudocereal grown annually in hilly regions of India. Its cultivation has declined in the 20th century. But now buckwheat despite being staple foods are underutilized because of the less knowledge of their functional properties among the locals, preferences of younger generation for new food under the ages of modernization and availability of new crops like rice on subsidized rates under PDS, etc (Hussain, 2020). Hence there is a need to research about this crop and create awareness to increase utilization.

Cultivation Practices :

Selection of site: Buckwheat is adaptable on well drained and fertile soil. Buckwheat is well suited to higher elevation area.

Soil: Buckwheat can be grown on a wide range of soil types, but it is best suited to light and medium textured soils, such as sandy loam, loam and silt loam, clay soils and highly fertile soils should be avoided. Buckwheat is as acid tolerant as oat or potato so that liming soils PH of 4-6 should not be necessary.

Climate: Buckwheat required cool and moist climates. It is not frost tolerant. Because of its short growing period. High temperatures and dry conditions during flowering may causes some flower blast and lower yields. Cool evening temperature and high humidity favour buckwheat growth. It is susceptible to lodging in heavy rain or wind. Buckwheat flowering at temperatures above 30°C but fruit dries out and the yield decreases.

Field preparation: When Buckwheat is sown in new fields, old pasture and weeds can be removed by ploughing several weeks before sowing. The soil should be harrowed periodically to improve its physical conditions, retain moisture and destroy weeds. At the time of sowing the field must be fine grain structure, adequate moisture and should be free from weed.

Improved Varieties :

VL Ugal -7 : This variety of buckwheat was released by ICAR-Vivekananda Parvatiya Krishi Anusandhan sansthan, Almora, UK in 1992 (SVRC). It is early maturing variety with flowering time of 65-70 days. The seeds are bold, black winged seeds with weight of 2.5 gm per 100 seeds. The flowers are white in colour. It has high yield potential of 10-12 q ha^{-1}. This variety have high protein (13.25%) and Lysine (5.5%) content. Beside this variety Himpriya, PRB-1,Himgiri, Sangla B1 Varieties are also used for cultivation of buckwheat crop.

Sowing :

Sowing time : The crop is generally sown in rabi season. Buckwheat can be sown from October-December can result in high yields because harvesting coincides with dry weather. To avoid the first frost in September and heat of July month, it is important to sow the earlier.

Crop Spacing : Buckwheat should be placed at 3-5 cm deep in line and kept 30-45 cm row-row spacing and 10-15 cm from plant-plant spacing depending upon varieties.

Seed rate: The seed rate of 20 kg ha^{-1} is advised as a sufficient amount for a productive grain yield.

Intercultivation : The crop emerges usually within 4-5 days after sowing. Gap filling was done immediately after emergence. Thinning was done at 15-20 days after sowing to keep the crop weed free, hand weeding was done twice to remove weeds in plot at 25 and 40 DAS.

Fertilizer requirement : General recommendation for added nutrients are follows :

22-45 kg ha^{-1} Nitrogen depending upon whether the crop is planted on summer fallow, pulse stubble or cereal stubble. Normal rate for phosphate range from (30-45 kg ha^{-1}). Potash is generally recommended if the crop grown on sandy loam soil. The suggested rate for potash in these cases would be 20-25 kg ha^{-1}.

Weed Control : Although buckwheat plants are very good competitor for weeds and generally fast growing capacity makes them a smoother crop. Under such conditions one weeding and hoeing are 20-25 DAS is helpful for raising a good crop. Firstly, the crop should be seeded into a fine firm and weed free seed bed. Secondly, the seed should be placed into moist soil to ensure quick germination and emergence. These practices help the crop compete with any emerging weeds. ICAR-NOFRI (ICAR-Sikkim) standardized use of mulches in buckwheat crop. Maize- stover + weed biomass mulch not only reduces the weed population but also enhances the water use efficiency in buckwheat.

Irrigation: Buckwheat grown during Rabi season. It has been found to respond favourably to application of irrigation. Buckwheat were irrigated two times with the irrigation norm of 60mm. The yield of irrigated buckwheat was 1235 kg ha^{-1}.

Suitable intercrop systems : Buckwheat can also be used as a cover crop. It takes up phosphorus and other nutrients that are otherwise unavailable to crops and releases them to later crops as the residue breaks down. Buckwheat intercrop with soybean, lathyrus and alfalfa, maize have been found profitable. It suppresses weeds and replace bare fallow. It can be planted after harvesting early vegetable crops, winter wheat or canola. Buckwheat is a potential crop for cultivation at higher altitudes because it can adopt to different climatic variables and water stress regimes.

Plant Protection:

Diseases : There are few reports of diseases in buckwheat. Leaf spot caused by a fungus called Ramilaria can occur. Rhizoctonia (root rot), downy mildew and aster yellows have also been found. None of these diseases is of any economics importance.

Insects: Japanese bettles, aphids, cutworm and wireworms have all been reporteol in buckwheat. Japanese beetles do the most damage attacking the flower head and an occasion can cause major economic loss.

Harvesting : Buckwheat has an indeterminate growth habit. The optimum time to harvest buckwheat is when the grains are mature but the plants is still green. When the seeds turn a dark brown, it means it is ripe and ready to be harvested. This happens 8-10 weeks after the seeding. Commercial farmers use swathing or winding methods to remove the seeds but a small crop, you can use threshing to remove the seeds.


Yield : The average yield of buckwheat is 8-15 q ha^{-1}.

Future Prospects : Buckwheat is highly nutritive crops helps in preventing many types of diseases of human being (heart related diseases). This is having high potential which is still untrap especially economic benefit.

Conclusion

Buckwheat can be the future food crop for feeding the mankind in fragile hill ecosystems. In order to arrest the declining interest of farmers in buckwheat cultivation in hilly regions, immediate attention of researcher, developer and scientist is required for developing new technologies and varieties as described above, the yield of buckwheat in hills and plains can be substantially increased.

There is a lot of scope for increasing the yield of buckwheat in india by using efficient agronomic management practices of the crop.

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ISSN : 2583-0910
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Peer reviewed
monthly newsletter

Article ID : 04/XII/10/1224

ROLE OF VARIOUS COLOURING PIGMENTS WITHIN DIFFERENT VARIETIES OF CARROT

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Abstract
The diversity in colour among fruits and vegetables is primarily attributed to the presence of various pigments, whose molecular structures and conjugation patterns determine their colour intensity. Among the key pigment classes influencing the colour of fruits and vegetables are chlorophylls, carotenoids, and anthocyanins, with carotenoids and anthocyanins being particularly prevalent in fruits. Carotenoids, such as α-carotene, β-carotene, and lycopene, along with oxygenated carotenoids like lutein and zeaxanthin, contribute significantly to the vibrant hues of these produce. In carrots, carotenoids and anthocyanins together create a remarkable diversity of root colours, ranging from white to black, and red to yellow. The conjugation within these pigments often enhances their colour intensity, which also correlates with various health benefits, particularly their antioxidant properties. These pigments, especially β-carotene, play an essential role in human nutrition due to their provitamin A activity, which supports visual and immune health. This review highlights the molecular diversity of pigments in carrots, exploring their structural characteristics, colour manifestations, and significant health benefits, thereby underlining their importance in both agriculture and human nutrition.

Keywords: Pigments, carotenoids, anthocyanins, β-carotene, provitamin A, antioxidants, colour diversity, health benefits.

Introduction:
Carrots (Daucus carota L.) are a rich source of essential nutrients and are cultivated in a wide range of colours, which vary from orange to purple, yellow, red, and even white. The diverse colour spectrum of carrots is primarily attributed to the presence of various colouring pigments, which not only contribute to the visual appeal of the vegetable but also play a significant role in its nutritional and health benefits. The primary pigments in carrots include carotenoids, anthocyanins, and flavonoids, each contributing distinct colours and bioactive properties (Zhao *et al.*, 2020). Carotenoids, especially β-carotene and α-carotene, are the most abundant pigments in orange and yellow carrots, responsible for their characteristic hues. These carotenoids are important precursors of vitamin A, contributing to the prevention of vitamin A deficiency and supporting visual and immune health (Krinsky & Johnson, 2005). Lycopene, another carotenoid, imparts a red colour and has been linked to antioxidant and anticancer properties (Bohm *et al.*, 2012). Additionally, xanthophylls like lutein and zeaxanthin, which are oxygenated forms of carotenoids, are found in yellow and green carrots and play roles in protecting the eyes from oxidative stress (Ma *et al.*, 2013). Purple and red carrots contain anthocyanins, a group of water-soluble pigments that provide a range of colours from red to purple and are known for their potent antioxidant properties. These pigments have been shown to reduce oxidative stress and inflammation, contributing to

cardiovascular health and potentially reducing the risk of chronic diseases (Luo *et al*., 2018). The presence of multiple pigments in carrots allows for the expression of various hues, which not only have aesthetic value but also indicate the presence of a variety of health-promoting compounds. The significant diversity in pigment composition across carrot varieties underscores the importance of breeding strategies aimed at enhancing the nutritional value of carrots through the optimization of these pigments. Understanding the roles and health benefits of these pigments is crucial for improving the functional properties of carrots, which are among the most widely consumed vegetables globally.

Figure -1 colour diversity in carrots

Carrot pigments and their biochemical roles

Carotenoids in carrots

Carotenoids are a large group of naturally occurring pigments responsible for the red, orange, and yellow colours in many fruits and vegetables. They are also precursors of vitamin A, which is essential for various bodily functions. Carotenoids are fat-soluble and are absorbed by the body during digestion. In carrots, the primary carotenoids are β-carotene, α-carotene, lutein, zeaxanthin, and lycopene.

β-Carotene

β-Carotene is the most well-known carotenoid in carrots and is primarily responsible for the orange colour of the root. It is a precursor to vitamin A, which is vital for maintaining healthy vision, immune function, and skin integrity. When consumed, β-carotene is converted into retinol (vitamin A) in the liver, providing the body with the necessary amounts of this vitamin. β-Carotene is also a potent antioxidant, neutralizing free radicals that can damage cells and lead to diseases like cancer and cardiovascular disorders.

Health benefits of β-carotene:

- **Eye health**: β-carotene is essential for the synthesis of retinol, which helps prevent night blindness and other visual impairments.
- **Antioxidant properties**: As an antioxidant, β-carotene helps prevent oxidative damage to cells and tissues, reducing the risk of chronic diseases such as cancer and heart disease (Krinsky & Johnson, 2005).
- **Immune support**: Vitamin A derived from β-carotene strengthens the immune system and enhances the body's ability to fight infections (Liu, 2007).

α-Carotene

α-Carotene, like β-carotene, is a provitamin A carotenoid, though it has a lower vitamin A conversion efficiency. α-Carotene contributes to the yellow-orange colour in carrots, especially in varieties like yellow carrots. It is believed to have additional health benefits, particularly in reducing the risk of certain chronic diseases.

Health benefits of α-carotene:

- **Cancer prevention**: α-Carotene has been shown to reduce the incidence of various cancers by neutralizing free radicals and preventing oxidative damage (Agarwal & Rao, 2000).
- **Heart disease**: Higher intake of α-carotene has been linked to a lower risk of cardiovascular diseases, likely due to its antioxidant effects (Goncalves *et al.,* 2005).

Lycopene

Lycopene is another carotenoid found in small amounts in some varieties of carrots, particularly red carrots. It is responsible for the red colour and is an important antioxidant. Lycopene has been widely studied for its role in cancer prevention, particularly prostate cancer, and cardiovascular health.

Health benefits of lycopene:

- **Cancer Prevention**: Lycopene has been extensively studied for its ability to reduce the risk of prostate cancer by inhibiting cancer cell growth (Bohm *et al.*, 2012).
- **Cardiovascular Health**: Lycopene helps in reducing oxidative stress and inflammation, factors that contribute to heart disease (Rao & Rao, 2007).

Lutein and Zeaxanthin

Lutein and zeaxanthin are carotenoids found primarily in yellow and green carrots. These carotenoids are essential for eye health as they accumulate in the retina and protect the eyes from oxidative damage caused by exposure to sunlight. Lutein and zeaxanthin have been shown to play a key role in preventing age-related macular degeneration (AMD), a leading cause of blindness in older adults.

Health benefits of lutein and zeaxanthin:

- **Eye Protection**: These carotenoids help protect the retina from harmful UV light and oxidative stress, reducing the risk of cataracts and macular degeneration (Ma *et al.*, 2013).
- **Skin Health**: Lutein and zeaxanthin have been found to improve skin hydration and elasticity, contributing to healthy skin aging.

Anthocyanins in carrots

While carotenoids contribute to the orange, yellow, and red hues of carrots, **anthocyanins** are responsible for the purple, red, and blue colours found in certain carrot varieties. Anthocyanins belong to the flavonoid family and are water-soluble pigments that have potent antioxidant and anti-inflammatory properties. They are found in significant amounts in purple carrots.

Types of anthocyanins

The main anthocyanins in carrots are **cyanidin**, **pelargonidin**, and **delphinidin**, with cyanidin and pelargonidin being most common in red and purple carrots. The presence of these anthocyanins is linked to several health-promoting properties, including enhanced antioxidant activity and protection against inflammation.

Health benefits of anthocyanins:

- **Antioxidant activity**: Anthocyanins neutralize free radicals and prevent oxidative stress, protecting cells from damage and reducing the risk of chronic diseases (Luo *et al.*, 2018).
- **Anti-inflammatory effects**: Anthocyanins have been shown to reduce inflammation, which is a key factor in the development of conditions like arthritis, cardiovascular disease, and diabetes (Cao *et al.,* 2015).
- **Cancer prevention**: Research indicates that anthocyanins may inhibit the growth of cancer cells and prevent metastasis (Wang & Stoner, 2008).

Table 1: Comparison of carrot pigments and their health benefits

Pigment	Colour	Carrot Varieties	Health Benefits
β-Carotene	β-Carotene	Orange, Yellow	Vitamin A precursor, antioxidant, supports eye health, immune function, and reduces the risk

Pigment	Colour	Carrot Varieties	Health Benefits
			of chronic diseases such as heart disease and cancer.
α-Carotene	Yellow-Orange	Yellow, some orange	Antioxidant, supports eye health, reduces cancer and heart disease risks, vitamin A precursor (less potent than β-carotene).
Lycopene	Red	Red, Purple	Antioxidant, protects against prostate cancer, heart disease, and oxidative stress.
Lutein	Yellow-Green	Yellow	Eye health, protects against age-related macular degeneration and cataracts, supports skin health.
Zeaxanthin	Yellow-Green	Yellow	Eye health, protects against UV light damage, reduces the risk of macular degeneration and cataracts, supports skin health.
Anthocyanins	Red/Purple	Purple, Red	Antioxidant, anti-inflammatory, cancer prevention, reduces oxidative stress, protects against heart disease and diabetes.

Health implications of carrot pigments

The pigments in carrots are not just aesthetically important but also play a crucial role in promoting health. The antioxidant, anti-inflammatory, and anticancer properties of carotenoids and anthocyanins contribute to the prevention of several chronic diseases. Carotenoids like β-carotene and α-carotene play key roles in vision health, immune function, and skin integrity. Lycopene, lutein, and zeaxanthin, found in varying quantities in carrots, are particularly beneficial for eye health. Anthocyanins, although less common in carrots, provide potent antioxidant benefits and contribute to the prevention of cancer, cardiovascular disease, and inflammatory conditions. Furthermore, the presence of multiple pigments in carrots means that consumers can enjoy a variety of health benefits, depending on the carrot variety consumed.

Breeding for enhanced pigmentation in carrots

The demand for nutritionally enhanced crops has led to an increasing interest in breeding carrots with elevated levels of carotenoids and anthocyanins. For instance, purple carrots, rich in anthocyanins, are being promoted for their enhanced antioxidant properties, while orange and yellow carrots are being developed with higher levels of β-carotene and α-carotene to meet the global demand for vitamin A-rich foods. Recent breeding efforts have focused on enhancing the bioavailability of these pigments, ensuring that the human body can absorb and utilize these compounds effectively. Such advancements in breeding technology are expected to improve the overall health benefits of carrots and make them a more integral part of a healthy, balanced diet.

Conclusion

The diverse colours of carrots, from orange to purple, red, and yellow, are the result of different pigment profiles that offer unique health benefits. Carotenoids like β-carotene, α-carotene, lutein, and lycopene, along with anthocyanins, contribute to the carrots' antioxidant properties, eye health benefits, and potential cancer-preventive effects. As research continues to uncover the full range of health benefits associated with these pigments, the future of carrot breeding and consumption looks promising, with enhanced varieties that support public health and nutrition. By understanding the role of these pigments, breeders can develop carrots with optimal pigment concentrations, enhancing their nutritional and health benefits. Such advances in carrot breeding can lead to more colourful and functional varieties, ultimately benefiting consumers and contributing to the fight against chronic diseases.

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
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Article ID : 04/XII/11/1224

COMMERCIAL PROPAGATION METHODS IN LOTUS PLANT (*Nelumbo Nucifera*)

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Introduction

The lotus represents human immortality or divinity. A perennial herb grown for its aesthetic qualities; the lotus is an aquatic plant. The Nelumbonaceae family contains two fundamental species: *Nelumbonucifera* and *Nelumbolutea*. The lovely pink and yellow blooms are traditionally presented to the gods and have a light perfume. It is naturally being spread by rhizomes and seeds. However, rhizome fragments have also been used as explants in tissue culture micropropagation, which has been standardized. It has long been admired for its capacity to maintain its purity and innocence in the face of its expanding surroundings. China brought lotuses to Japan and other countries, where they were grown for almost a millennium. The majority of plants in the northern hemisphere became extinct throughout geological shifts, especially during the Ice Age when temperatures were low, yet lotus flowers survived. In practically every region of our nation, lotuses are found naturally. It is utilized in the floriculture industry as a potted plant, cut flower, and loose bloom, as well as in the landscaping of large lakes and ponds. In addition to its usage in floriculture, lotus is a plant whose roots, stems, leaves, flowers, and buds are all commercially used in food or traditional medicine. It can be grown economically by applying fertilizer, managing ponds, and other techniques. After harvest, petal blackening can be minimized by using improvised post-harvest techniques.

The commercial cultivation of this crop in our nation has received little attention, despite its considerable economic significance. Research on the commercial cultivation of this crop in India is necessary, as is the planning of training programs for farmers and business owners who wish to start growing it. Since the floral industry thrives on innovation, this long-forgotten traditional flower has made a comeback in contemporary décor, where lotuses are now a popular choice.

Uses of lotus

Every component of the lotus flower, seed, leaf, and roots has a variety of uses. Cut flowers, loose flowers for landscaping, and dried flowers and their derivatives are all utilized in floriculture.

Lotus Flower Uses: Using Lotuses for Wedding Decorations, Using Lotuses as Potted Plants (Indoors or Outdoors), Using Lotuses as Dry Flowers.

Cultivation methods : **1)** Natural 2) Man Made Ponds for Commercial Purposes
Propagation methods : 1) Seeds **2)** Rhizomes **3)** Tissue culture

Lotus is frequently grown for a variety of purposes in shallow lakes, containers, rice fields, and ponds. The ideal planting season usually lasts from late March to early May, though this depends on the local climate. Seeds, bigger rhizomes, spreading rhizomes (runners), single-node buds, terminal buds of stems, and tissue culture are some of the methods used to grow lotuses.

Seed: The longest known viability with age has been seen in seeds. The unusually hard, impenetrable seed coat is what gives them their lengthy lifespan. Scarifying the seed coat and then incubating it for 16 hours at 25 to 30 degrees Celsius is one method of seed propagation. (Shen-Miller *et al.,* 1995).

In actuality, compared to rhizomes, seed propagation saves a lot of money, time, and labor while producing plants across a broad region quickly. Breeding programs also benefit greatly from seed propagation. Furthermore, lotus seed propagation can reduce disease incidence without compromising yield. However, due to natural seedling variability, seeds are not recommended for use in conservation or in the creation of a true-to-type species or variation. Certain non-flowering rhizome lotus and double-flower varieties do not have seeds available (Zhou *et al.,* 1989).

Meyer (1930) studied the growth and dormancy of the American lotus, N. lutea. The findings indicated that whereas development was severely limited below 15 ºC, it was significantly accelerated at higher temperatures between 20 and 30 ºC. In the meantime, soil types and pH had a significant impact on plant development. According to Masuda et al. (2006), long days and high temperatures promoted the growth of vegetables, but short days, not temperature, were the primary environmental element that caused lotus plants to enter dormancy.

Rhizomes: The simplest and most effective way to propagate plants is through rhizomes, which also yield true-to-type plants. The present crop is used to supply rhizome, or a separate mother pond is built to supply seed rhizome material for each succeeding season (Nguyen, 2001).

Tissue culture: Tissue culture may offer an alternate strategy for lotus propagation in addition to conventional approaches. When an established industry purchases seed material from a specialist in creating seed rhizomes, this approach shows potential for the future. Tissue culture would be used by a grower to generate large amounts of consistent, disease-free, true-to-type material.

Growers would be able to maximize their planting area as a result. For supplied seed to be a feasible option, it must be of a higher quality level and less expensive than what a farmer might generate (Nguyen, 2001).

Conclusion

Lotus is an important aquatic floriculture plants which are grown for its flower, seed, leave as well as rhizome as vegetable. Propagation methods need to be commercialized for large scale cultivation for the present demand of the market. It can be propagated by rhizome, seed and tissue culture plantlets however among this planting materials, rhizome as planting propagules is the cheapest and easy method as compare to seed and tissue culture method. Therefore, for the large-scale cultivation rhizome as planting materials can be recommended for the lotus growers in India for its cultivation.

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Fig 1. Lotus seed

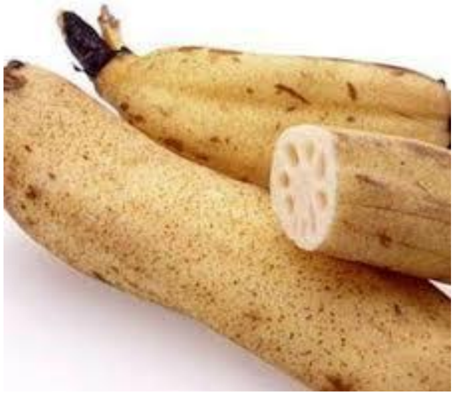

Fig 2: Lotus rhizome

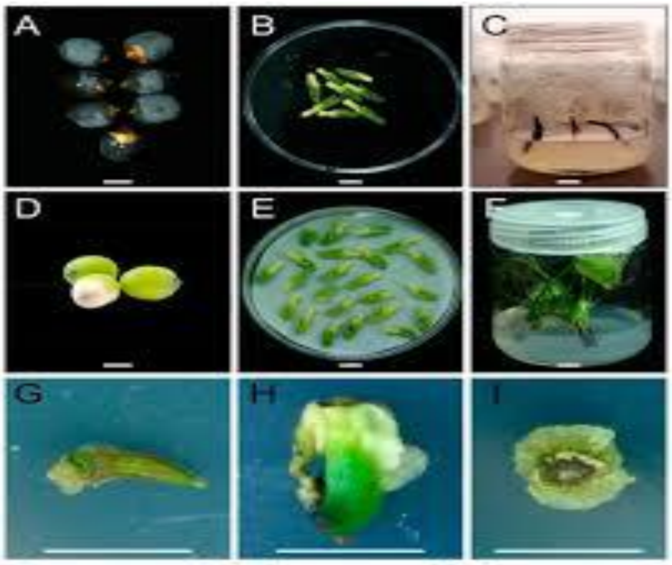

Fig 3: Tissue culture in lotus

ISSN : 2583-0910
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Article ID : 04/XII/12/1224

DRAGON FRUIT – THE MIRACLE FRUIT OF THE MORDEN ERA

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The tropical fruit known as dragon fruit, or pitaya or pitahaya, is indigenous to Central and South America. It is distinguished by its vivid appearance and distinct texture and is a member of the cactus family. The fruit's flesh can be white, pink, or red, with tiny black seeds scattered throughout. Its skin is usually bright pink or yellow with green scales. Dragon fruit is praised for both its eye-catching look and its cool flavour, which is frequently compared to a hybrid between a pear and a kiwi. It is a well-liked option for consumers who are health-conscious because it is low in calories but high in antioxidants, vitamins, and minerals. Dragon fruit can be consumed raw, mixed into smoothies, added to fruit salads, or even used as a colourful garnish. Its exotic appearance and nutritious profile have contributed to its growing popularity worldwide.

Introduction

Dragon Fruit (*Hylocereus undatus*) production is becoming more widely recognized as an important crop. It is a valuable plant with numerous health benefits, but it has yet to gain popularity among Indian cultivators. This is a relatively new concept in India, with on-going experimentation at both the institute and farmer levels. Dragon fruit (*Hylocereus* spp.) is currently gaining popularity among Indian cultivators, not only for its interesting red or pink color and potential for profit as a fruit, but also for its high antioxidant, vitamin, and mineral content. It is rich in Protein (1.1 g), Fat (0.4 g), Carbohydrates (11.0 g), Fiber (3 g), Vitamin B1/Thiamine (0.04 mg), Vitamin B2/Riboflavin (0.05 mg), Vitamin B3/Niacin (0.16 mg), Vitamin C/Ascorbic Acid (20.5 mg), calcium (8.5 mg), Iron (1.9 mg) and Phosphorus (P) 22.5 mg. (FAO, 2002). Fruit pulp can be consumed either raw or processed into several high-value items. The dragon fruit production industry has been shown to provide a viable source of food, revenue, and employment for producers both locally and globally (Li, Y., and H.E. Schellhorn, 2007). It is profitable to both producers and consumers. It could be beneficial to both backyard farmers and entrepreneurs operating mid and large-scale plantations. Dragon fruit is mainly available in different variants viz., red skin with white pulp (*Hylocereus undatus*), red skin with red pulp (*Hylocereus monacanthus* previously known as *H.polyrhizus*) and yellow skin with white pulp (*Hylocereus megalanthus* previously known as *Selenicereus megalanthus*) (Fig.1).

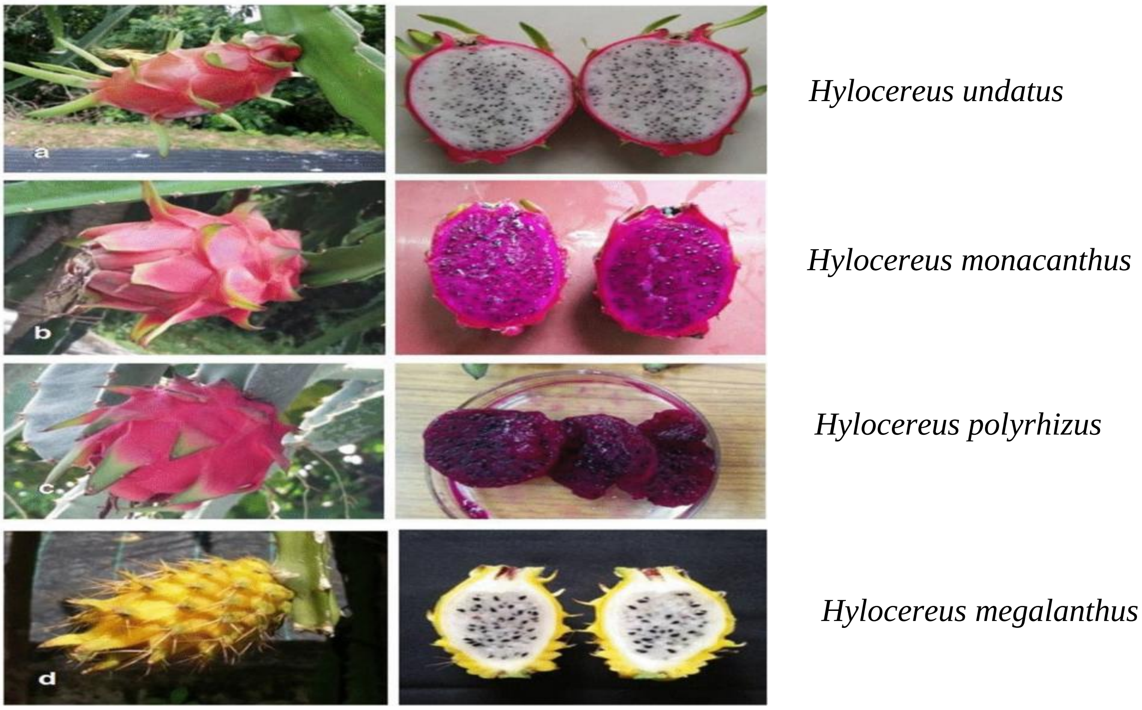


Fig.1: Different types of Dragon fruit on the basis of skin & pulp colour.

Soil and climate

As a member of the Cactaceae family, dragon fruit requires ample of water in comparison to other cacti, it is native to the tropical rainforest. Thus, it is perfect to grow across most of India, with the exception of regions that receive less rainfall. Commercial dragon fruit cultivation is feasible up to an elevation of 1700 metres, and the fruit requires 1145–2540 mm of rainfall annually (Feng-ru and Chung-Ruey, 1997a; 1997b). The dragon fruit plant thrives in dry tropical climate with typical temperatures between 20 and 29 ºC, although it can tolerate temperatures as low as 0 ºC for brief periods of time. Temperatures over 40°C will harm the plants, resulting in stem yellowing. Areas with high rainfall are unfavorable for growing crops since it might lead to flower and fruit drop. Although its roots are shallow (less than 40 cm), it can be grown in a variety of soil types as long as there cannot be too much moisture present. On the other hand, commercial dragon fruit orchard farming prefers slightly acidic (pH 5.5–6.0) loamy soil that is rich in organic matter. Considering that the desired region is sub-marginal, an organic fertiliser will be used to make up for the soil's deficiency in organic matter (Karunakaran, *et.al.,* 2019).

Land preparation and planting

Dragon fruit cultivation prefers full sunlight, thus open places are suited for planting. They should not be planted in severely shaded areas or wetlands patches and their soil should be drained. Avoid windy areas as strong consistent winds can damage the trellises or other types of support provided for the stems. Generally, in a single post system, planting is done at a 3x3 m distance. The suggested spacing of 3.0-4.0 m × 3.0 m ensures proper air circulation and reduces the probability of disease incidence, but in low fertile dry land locations, a higher density population of plants is recommended (3.0 m x 2.5 m spacing) to make up for yield reduction per unit area (Tripathi, *et.al*., 2014). When planting, adding dolomite and organic fertilizer is advantageous. The media was made of soil that was enriched with biofertilizers and organic materials such as farmyard manure, coir compost, and vermicomposting. At least 1½ to 2 inches deep, plant the hardened cuttings straight into the ground. To make ascending easier, place the dragon fruit close to the poles. Depending on the climate, a pole may have two to four plants in total.

Propagation

The majority of dragon fruit is reproduced vegetatively by cuttings. To produce healthier plants, utilize the full stem segment or a portion of the stem segment of a mature cutting measuring 15-30 cm. These cuttings are placed in 12 x 30 cm plastic bags filled with a 1:1:1 mix of soil, farmyard manure, and sand. The bags are maintained in a shaded area for roots. High moisture levels should be avoided to prevent cutting rot. After 5-6 months, these cutting roots will be ready for planting in the main field. To prevent diseases, particularly rots, cuttings should be treated with fungicides and kept in a cool, dry location for 5-7 days before planting. Seed propagation research revealed that seedlings remained smaller with thinner stems even after a year of planting. In addition, plants grown from seeds are not true to type, and there is an immense amount of variance among them (Tripathi, *et.al*., 2014).

A. Leaf cutting B. Dragon fruit plant

Fig. 2: Vegetative propagation in Dragon fruit by stem cutting.

Training and pruning

The dragon fruit vine requires support from concrete, wooden poles, or wall columns because it is a climbing cactus and an epiphyte. The juvenile stem must be linked to the column for aerial roots to form and become bound to it. Peripheral shoots are limited and only 2-3 primary stems are permitted to grow (Fig.3). The column selected must be persistent and strong enough to withstand the weight of the vine canopy, which is greater than 100 kg, thus cement or solid hardwood posts are suggested. For this, most cement poles/posts with a height of 2 m are used, which should be placed 30-40 cm on the ground's surface. The concrete rectangular or circular frame or tyre is attached to the top of the pole to droop the stems downward. Steel wires and iron frameworks are not supposed to be used as they may cut and injure the vines. The anchoring post should be installed before planting to ensure that it is firm enough for the vine to climb up. Four plants ought to be placed around each pole. Planting is normally done during the season of rainfall, followed by the formation of suitable ridges of 50 cm in height to provide support to the plants.

As the vines grow rapidly, the probability of lodging and falling to the earth doubles. To prevent this problem, tie the vines and prune the lateral branches regularly. In mechanical pruning, only the outermost leader vine is allowed to grow until it reaches the 7th top of the trellis; after that, unlimited branching is permitted. Pruning should be done in the month of May which stimulates heavy flowering and fruiting. The total number of branches must be reduced to 30-50 by cutting the unnecessary branches, which is referred to as production training. After harvest, around 50 main branches with one or two secondary branches on the primary branch are to be retained, eliminating the tertiary and quarterly branches with the cut ends treated with fungicide. Cutting the tip of the primary stem growing new shoots to develop laterally and climb to the ring, forming an umbrella-like structure of vines. Postharvest pruning stimulates the sprouting of new branches, which produce flourishes the following year. A healthy vine can develop 30-50 branches each year and up to 100+ branches in four years. The plant is a climber cactus with segmented stems. They rely on aerial roots to attach themselves to supports. Plants can survive for 15-20 years and can weigh up to 100kg each. Commercial orchards require a well-designed trellis system (Mori *et al.,* 2023).

Single stands

Support is provided by the rings and single cement posts. On top of the posts in certain places are rubber tyres with cuts in them. Depending on the climate, 2-4 plants per pole can be placed close to the posts to facilitate easy climbing.

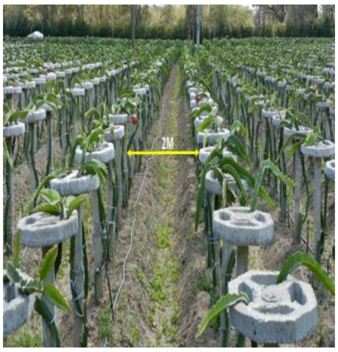
'T' stands

The stand's structure is in a "T" shape. The plant is positioned in the space between two poles. The initial outlay is substantial-roughly 6-6.5 lack/acre. After the fourth year, things start to cloud and there's a higher probability of insect pest attacks. Farmers do not favor it.

Continuous pyramid stands

Continued type Stands are contained of G.I. pipe but G.I. angles can also be utilized. This pyramid has a length of 15 meters long. A greater number of fruit plants may be planted in this system. Providing proper aeration into this system helps to prevent illness and pest infestation. Plants can be planted at a 2-3 foot distance on both sides of the structure. The spacing between two structures may be 5-6 m.


A.

B.


C.

D.

E.

Fig. 3: Training system in Dragon fruit

A,B,C & D: Concrete rectangular or circular frame or tyre is attached to the top of the pole to droop the stems downward.

Manure and fertilizer

For maximum crop yield efficiency, suitable nutritional requirements must be fulfilled. Dragon fruit is not an exhaustive fruit crop, but with a superficial root structure, it can soak up a small amount of nutrients. A careful application of manures and fertilizers is required for improved fruit output and quality. Different fertilizer dosages have been noticed in various countries. For plants between 1 and 2 years old, 10 to 15 kg of FYM is recommended, while plants over 3 years old ought to get 20 kg. It can be cultivated organically, without using chemical fertilizers or pesticides. Organic fruits are in higher demand in the market. Oil cakes, beneficial microorganisms, and organic manures proved highly effective in dragon fruit production (Mori *et al.,* 2023). At intervals of three to four months, a combination of organic manure with neem cake is applied, together with 100g of complete fertilizer (19-19-19). Pruning plants regularly produces an open, manageable canopy and encourages new shoots for the following cropping season (Karunakaran *et al*., 2014).

Irrigation requirement

Dragon plants can thrive with inadequate rainfall and prolonged periods of drought; nevertheless, when good-quality fruits are desired, a consistent water supply is crucial. Regular irrigation is vital because it allows the plant to accumulate enough reserves not just to flower at the ideal moment, but also to ensure fruit growth. It possesses a good utilization of water and requires less water than C-3 and C-4 crops. It spreads out aerial roots from the stem's sides to collect water and anchor itself. It takes only 10% of the water needed by most other fruit crops, including pear, citrus, and peach. To meet its water requirements, it is recommended to apply 120 to 150 mm of irrigation each year. Dragon fruit's root system is shallow, ranging from 15 to 30 cm deep. As a result, irrigation should be ensured to provide adequate water throughout the drought. Excessive watering may result in fungal diseases. Therefore, appropriate drainage should be maintained throughout the rainy season. The quantity and quality of fruit are harmed by frequent dry spells without watering. To produce more fruits, the dry period before flowering is required. It has been shown that local drip irrigation is beneficial for boosting growth and output. Flood irrigation is not suggested since it loses water and increases the labour of weeding (Mori *et al.,* 2023).

Harvesting

Harvesting occurs primarily between July and November, with 6-7 flushes. During the initial fruit development cycle, the outer skin of immature fruit is bright green and progressively turns 85% pick as ripening occurs. The dragon fruit matures 30-35 days after flourishing. Simply moving the fruit clockwise and twisting the fruit does little or no damage to the fruits. Another advantage of the crop is that fruit can be harvested at different times based on market needs. Fruit harvested three to four days after the skin color changes from green to red/pink, but it can be harvested a day later for far markets/export purposes (Mori *et al.,* 2023).

Yield

It is a fast-returning perennial fruit crop. In well-managed orchards, flowering can begin as early as the second year, with potential yield realized in the second or fourth year. The average production might be 10 to 12 tonnes per hectare. However, in organized commercial orchards, yields of 16-27 tonnes/ha are feasible from the third year onwards under favourable climatic and management conditions. The standard weight of fruit is 300-800 g (Mori *et al.,* 2023).

Conclusion

Dragon fruit is expected to be very marketable in the region because of the high demand and comparatively small number of commercial growers. It is possible to grow dragon fruit in India during the off-season, when prices can range from INR 150.00 to INR 250.00 per kilogram. Given the anticipated future growth in production, marketing strategies need to be thoroughly thought out. The continually growing area dedicated to dragon fruit production makes research and development a priority. It is possible to cultivate dragon fruit in areas with better irrigation availability and dry weather. If the cultural traditions are examined for integration into the current frame system, farmers in these areas will greatly benefit. As a result, the government and policymakers must be encouraged to strengthen dragon fruit cultivation in the arid and semi-arid regions to take advantage of its economic and nutritional benefits.

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Article ID : 04/XII/13/1224

FOXTAIL MILLET: A TRADITIONAL CROP IN MODERN TIMES

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Introduction

Millets are cereal crops from the Poaceae grass family and are considered one of the oldest cultivated crops. Millet is one of the most important drought- resistant crops and the 6th cereal crop in terms of world agriculture production. Also, millets are pest and disease resistant, short duration, and high yielding as compared to major cereal crops (Devi and others 2011). Millets are small-seeded crops with different varieties such as pearl millet (*Pennisetum glaucum*) , finger millet(*Eleusine coracana*),Kodo millet(*Paspalum setaceum)*,Proso millet (*Penicum miliaceum*), Foxtail millet *(Setaria italic)*, Little millet (*Penicum sumatrense*)and Barnyard millet (*Echinochloa utilis*).Generally, Pearl millet (*Pennisetum glaucum*) and Finger millet (*Eleusine coracana*) are known as two major millets used for food and feed. Millet offers both nutritional and livelihood security for human beings and also food security for diverse livestock populations in dryland regions of rural India. Pearl millet and Finger millet account for most of the world's millet production and trade.

Foxtail millet is one of the oldest of the cultivated millets in the world, is cultivated in about 23 countries in Asia, Africa and America. It is a self-pollinating, short duration, C_4 cereal, good as food for human consumption, feed for poultry and cage birds and fodder for cattle. Foxtail millet ranks second among the millets production in the world and continues to have an important place in the world agriculture providing food to millions of people dependent on poor or marginal soils in southern Europe and in temperate, subtropical and tropical Asia. In India, it is grown mainly in Andhra Pradesh, Karnataka, Tamil Nadu , Madhya Pradesh , Uttar Pradesh and in a small extent in the northeast states of India. Foxtail millet requires warm weather and matures quickly in the hot summer months. Generally grown in semi-arid regions, it has a shallow root system. Diseases affecting foxtail millet including mildew, bacterial blight and leaf spots. Kernel smut is also a problem in some cases; it can be controlled with seed treatments at planting.

Foxtail millet is used as an energy source for pregnant and lactating women and for sick people and children. Foxtail millet is rich in dietary fibre, minerals, micronutrients, protiens and has low glycemic index (GI). It releases glucose steadily without affecting the metabolism of the body unlike rice.

Cultivation aspects : Foxtail millet has a slender, erect, leafy stem varying in height from 1-5 ft and bends quite a bit at maturity due to heavy weight of earhead. Leaves are narrow (30-45 cm long and 1.25cm wide) and green in colour. The inflorescence is a dense, cylindrical spike with short side branches bearing spikelets and bristles. The spike is 5-32 cm long and 2-4 cm in diameter often arching towards the tip. Spikelets are two flowered, the lower one sterile and the upper one bisexual, with three stemens. Spikelets are protected by a pair of glumes and are generally in clusters of 40 or 50. There are 1-3 bristles at the base of each spikelet. The flowers open near midnight and in the morning. The maturity duration in foxtail millet varies from 60 or 100 days, but most of the popular varities mature in 75-85 days. It grows better in places with annual rainfall ranges from 500-700 mm and where rains fall during summer. Foxtail millet is frost sensitive and grows better between 16 and 26^{0}C. Foxtail millet requires fairly fertile soils for good yields, provided with a pH range of 5.5-8.3 and are not water logged. The crop has a low water requirement and poor recovery after a prolonged drought spell. Light soils including red loams, alluvial and black cotton soils are suitable for its cultivation. It thrives best in rich, well drained loam soils.

Recommended package of practices for foxtail millet

Operation	Practice
Land preparation	Plough once with mould board plough before the onset of monsoon, harrow or plough twice with local plough with the onset of monsoon . Field should be smooth and well – levelled.
Time of sowing	*Kharif*: July-Aug(Karnataka) , July (TN ,AP) , 2-3rd week of July (Maharashtra) *Rabi*: Aug- Sept.(TN) , *Irrigated/Summer*: Feb.-Mar.
Seed rate	10kg/ha (line sowing)
Spacing and optimum plant population	25-30 cm (row to row),8-10cm (plant to plant); 4-4.5 lakh/ha
Seed treatment	Fungicide : Ridomil mz@ 2g/kg, Carbendazim @ 2g/kg , Biofertilizers: *Azospirillum brasilense* and *Aspergillus awamori* @ 25g/kg
Manures and fertilizes (for rainfed crop)	FYM: 5-7.5 t/ha , Urea : 52 kg/ha , DAP: 33kg/ha
Intercultivation	Using a tyne- harrow when crop is 30 days old
Irrigation/ drainage	2-5 irrigations in summer crop depending upon soil type and climatic conditions ; excess rain water should be drained out to avoid water logging
Weed control	Isoproturon (0.5 kg ai/ha) (pre-emergent);2,4-D(0.75kg ai/ha)(post-emergent 15-20 DAS)
Disease control	Rogue out downy mildew affected plants , spray Mancozeb@2g/l if diseases appear at early stage of crop growth
Pest control	Early sowing in the month of May whenever possible , in case of late sown crop increase the seed rate one and half times and seed treatment with Chloropyriphos @ 2ml/l water for 1 kg seed or Imidachloprid @ 0.7 ml/l water.
Harvesting	Harvest when the earheads are dry either by cutting the whole plant by sickle or the ears separately .
Threshing	Thresh after drying for a few days with a stone roller or by tampling under the feet of bullocks
Intercropping	Andhra Pradesh: Foxtail millet : pigeon pea (5:1) Karnataka : Foxtail millet: cotton(5:1); Foxtail millet : field bean (4:2) ; Foxtail millet : pigeon pea (5:1)

Local names of foxtail millet

Language	Name
Hindi	Kangni, Kakum
Sanskrit	Kanguni
Kannada	Navane
Tamil	Tenai
Telugu	Korra, Korralu
Malayalam	Thina
Marathi	Kang, Rala
Gujarati	Kang
Punjabi	Kangni

Major production constraints

Blast disease caused by *Magnaporthe grisea*, is one of the major constraints for the production of foxtail millet. Blast affects both forage and grain production. Symptoms of the disease appear as circular spots with straw-coloured centers on leaf blades. The leaves wither and dry when the disease appears in severe form. Another important disease affecting foxtail millet is leaf spot (*Helminthosporium sp*.) , which is caused by at least three species of the fungus . Other frequently occurring diseases are downy mildew, sheath blight and rust.

Among the insect pests, shoot fly (*Atherigona atripalpis* wiede) is one of the important pests of in foxtail millet . Shoot fly infestation results in dead hearts leading to yield loss. Major monocot weeds affecting foxtail millet are *Digitaria marginata* , *Cynodon dactylon* , *Cyprus rotundus* , *Setaria glauca* , *Crommelina benghalensis* , etc. Among the dicots *Euphorbia hirta, Leucas aspera, Phylanthus niruri , Amaranthus viridis* , etc. are important . The field should be kept free from weeds for higher yields.

Summary

The spread of high yielding foxtail millet varities in different parts of the country is very much limited as organized seed production and supply is absent in most states. The yield gaps due to crop management constraints that mask the genetic yield potential of high yielding varieties under on-farm conditions in different states need to be addressed on priority. Blast and sheath blight tolerant varieties need to be developed. Utilization of Chinese male sterile lines and crossing with local adapted cultivars, identification of maintainers and restorers for hybrid development need to be focused. Awareness creation on the nutritional superiority among the urban population will boost the demand. As it is a climate change-compliant crop because of the potential abiotic stress tolerance, it can ensure ecological security also.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 04/XII/14/1224

GROUP DYNAMICS: THE KEY TO ENHANCE COLLABORATION AND EFFICIENCY

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In every corner of society, from workplaces to sports teams and community organizations, groups play a fundamental role. But what exactly makes a group? At its core, a group is a collection of two or more people who interact regularly, identify as part of a unit, and share common goals or values. Communication and interdependence connect members, forming a social network.

What is Group Dynamics?

Group dynamics is the patterns of interaction and relationships within a group, which shapes the group's success and influence its members. It was coined by social psychologist Kurt Lewin in 1951, this concept explores why groups form, how they evolve and the influence they have on individual members, other groups and larger organizations.

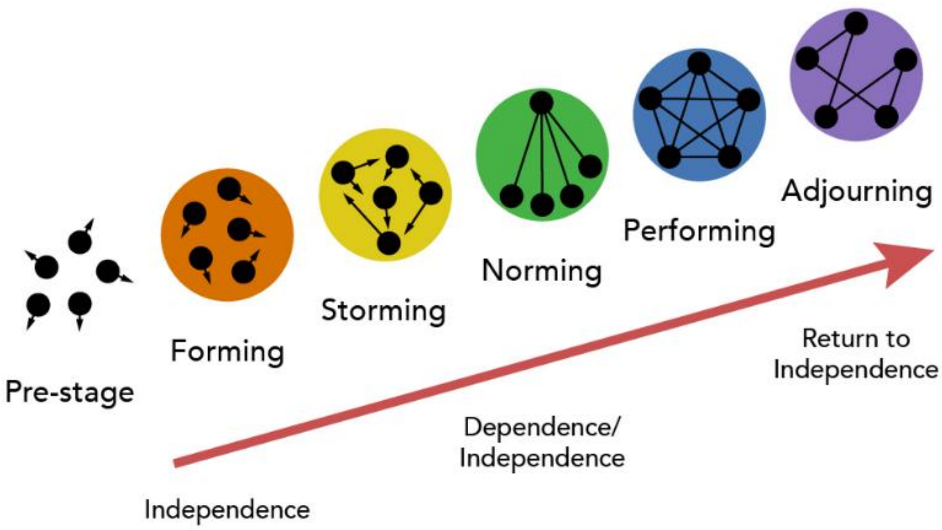
Lewin emphasized that understanding group dynamics is crucial to analyzingbehavior, decision-making, and even societal issues like prejudice and discrimination. Group dynamics can be studied across various fields, including psychology, sociology, business, and communication.

Group dynamics is dependent on:Communication processes and pattern of interactions

- Interpersonal attraction and cohesion
- Social integration and social influence
- Control of power
- Culture

Stages of Group Dynamics

Psychologist Bruce Tuckman (1965) in his paper "Developmental sequence in small groups" stated that there are five stages of group formation viz. forming, storming, norming, performing, and adjourning. Individuals having similar likings tend to form a group. As a new group comes together, its members are faced with a dilemma. People want to belong to groups. The group's common goal provides a sense of purpose, and self-selection homogenizes membership. At the same time, individuals also want to maintain their independent identities. Interpersonal and work-related behavior is exhibited and analyzed during the stages of group development.



In the **pre stage**, we have a group of people who have never met and probably do not yet know they're going to be a group.

At **forming stage**, everything is new. Forming effective relationships, learning to work together, and identifying shared goals are crucial. For teams with new leadership or members, this period involves testing behavior and relying on leadership for guidance in an unstructured environment. Members orient themselves to tasks and discover acceptable behaviors, transitioning from individuals to group members.

Characteristics of this stage include:

- Initial lack of unity
- Dependence on facilitators or leaders
- Uncertain interpersonal relationships
- Polarization around initial issues or tasks
- Efforts to define tasks and determine how to accomplish them.

At **storming stage**, group members typically have emotional responses to the task demands they start to recognize. They may become hostile or overzealous, as a way to express individuality and resist processes or the structure around group formation. Group members may also react emotionally to the extent of the task demands and the perceived requirements for self change and self-denial.

This stage is characterized by:
Infighting, defensiveness, and competition.

- Establishment of unachievable goals.
- Disunity increased tension and jealousy.
- Disruption and fragmentation
- Resistance to the task demands, because they are perceived to interfere with personal needs

The **norming stage** of group development is marked by a more serious concern about task performance. The dyads/triads begin to open up and seek out other members in the group. Efforts are made to establish various norms for task performance. Members begin to take greater responsibility for their group and relationship while the authority figure becomes relaxed. Once this stage is complete, a clear picture will emerge about the hierarchy of leadership.

This stage is characterized by the following:

- ❖ An attempt to achieve maximum harmony by avoiding conflict.
- ❖ A high level of intimacy characterized by confiding in each other, sharing personal problems and discussing team dynamics.
- ❖ A sense of a new ability to express emotions constructively.
- ❖ Group members feel part of something.

Performing is a stage of fully functional group where members see themselves as a group and get involved in the task. Each person makes a contribution and the authority figure is also seen as a part of the group. Group norms are followed and collective pressure is exerted to ensure the process of group effectiveness of the group. The group may redefine its goals in the light of information from the outside environment and show an autonomous will to pursue those goals.

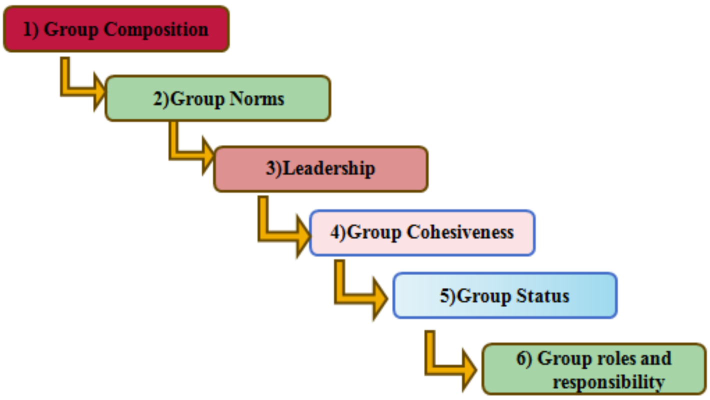
This stage is characterized by the following:

- ❖ Openness to other group members
- ❖ Understanding, analysis, and insight
- ❖ Mutual trust.
- ❖ Cohesion and mutual support.

Adjourning eventually, the group reaches its conclusion, either by completing its tasks or disbanding. Members reflect on their accomplishments and plan their next steps.

Components of Group dynamics

Effectiveness of group dynamics depends on some of the elements of organization



1. Group Composition

- It refers to the extent to which group members are similar
- Group Composition has an important role to play in influencing the group dynamics.
- The members of a group are either homogeneous or heterogeneous.

(a) Homogeneous Group: Members share similar qualities, leading to higher cohesiveness and fewer conflicts. However, they may struggle with diverse challenges due to similar personalities. Similarities might include demographic features, personality, abilities, or opinions.

(b) Heterogeneous Group: Members possess different qualities, resulting in lower cohesiveness and more conflicts. They are better equipped to handle varied challenges due to their diverse specialties and personalities.

Group Norms

- Norms are those standards which guide the behavior of the members of the group.
- These norms guide the members regarding what to do and what not to do in a particular situation and are required for the successful running of the activities of a group.
- These are normally unwritten (oral).
- Those members who fail to observe the serve the group boycotted.

For example, nobody will use mobile phone for personal use during the working hours in the office by the order of manager, gradually becomes a norm.

Leadership

- Group leadership is another element that influences the behavior of the members. Every group has a leader. The style of working of the leader has an effect on the behavior of the members of the group.
- Groups can be bothformal and informal.
- In formal group, leaders are appointed. Their ranks, powers and responsibilities are formally laid down. The main function of these leaders is to order and direct the members in the work.
- In informal group, leaders are not appointed but accepted because of their personality or skills. Such leaders help the members of the group in giving expression Meir thoughts

Group Cohesiveness

- Group cohesiveness refers to the closeness or similarity of attitude of the behavior and performance of the members of the group.
- Members of the cohesive effectively. group are united and work together effectively
- More cohesiveness leads to more cooperation, unity and liking among the members
- Group with more cohesiveness can achieve the objectives more effectively and quickly.

Group Status

- Group status refers to the position or rank of a person in a group which he gets because of his qualities. A person is recognized by his status and gets motivated by high rank. The behavior of a motivated person is different to others.
- In an organization, there are two types of status:

Formal Status : This is assigned based on official roles like general manager or supervisor, linked to qualifications and experience. It includes salary, authority and respect.

Informal Status : This is based on personal qualities, experience and personality. It reflects roles like informal leaders or influencers within the group.

Group Roles and Responsibility

- Role means the expected behavior from the members of the group. The expected behavior can either be clearly laid down or implied.
- In formal group, the role of the members is clear. Members make effort to fulfill their role effectively. This affects their behavior positively.
- In an informal group, the role of the members is not clear. It is not explicitly laid down. This unclear role of the members affects them negatively.
- It is therefore, clear that greater clarity about the role of the member would give them great satisfaction and they will work in all better way for the group.

Implications of Group Dynamics through Case Studies

Enhancing Organizational Success Through Effective Group Dynamics

Group dynamics play a vital role in shaping how teams function and succeed. In organizations, understanding group dynamics can help leaders create cohesive, high-performing teams. For example, the case of HasiruDala Karnataka (HDK), a waste picker organization, shows how clear roles and responsibilities within a group can lead to remarkable outcomes. HDK experienced a 20.00 per cent increase in waste collection efficiency and an 80.00 per cent improvement in members feeling valued and respected in their communities after implementing structured group dynamics.

Strengthening Community-Based Organizations (CBOs)

The study "Critical Analysis of Group Dynamics Effectiveness of Farmer Producer Organisations (FPOs) Members in Assam, India (2013)" by Singha*et al.* highlighted the significant implications of group dynamics on Community-Based Organizations (CBOs). It reveals that the majority of FPO members exhibited medium to high levels of group dynamics effectiveness, influenced by factors such as education, motivation, cohesiveness, and communication. These findings underscore the importance of fostering a positive group atmosphere and strong interpersonal trust to enhance the performance and productivity of CBOs. The study suggests that improving these dynamics can lead to better decision-making, higher member participation, and overall achievement of organizational goals, thus supporting the sustainable development and income generation for rural communities.

Boosting Self-Help Groups (SHGs) Performance

The study "A Study on Group Dynamics Effectiveness of Women's Self-Help Groups Members in Ahmedabad District of Gujarat (2021)" by Patel *et al,*the findings suggest that effective group dynamics significantly enhance the performance of self-help groups (SHGs). The high levels of group cohesiveness, leadership, and interpersonal trust observed among SHG members imply that fostering strong interpersonal relationships and effective communication within groups can lead to improved collective achievements and overall success. These results indicate that investing in activities and strategies that promote positive group dynamics, such as team-building exercises and leadership training, can be crucial for maximizing the effectiveness and productivity of SHGs.

Enhancing Agricultural Programs through Group Dynamics

The study conducted by Aisyah*et al,* in PakapasanHilir Village, Hantara District, Kuningan Regency, Indonesia, explored the relationship between farmer group dynamics and the success of farmer empowerment programs through agricultural technology and information. Findings revealed that high scores in various aspects of group dynamics—such as clear goals, complex structure, effective functions, smooth development, compact unity, and conducive atmosphere were strongly correlated with the success of agricultural programs, with a correlation coefficient of 0.889. The study highlights that effective group dynamics significantly enhance the success of agricultural programs by fostering better cooperation, communication, and overall group performance, leading to successful implementation and adoption of agricultural technologies and information.

Improving Tribal Farmer Producer Groups (FPGs)

To enhance the effectiveness and sustainability of tribal Farmer Producer Groups (FPGs) in Srikakulam district, Andhra Pradesh, the study conducted by Srikar*et al.* emphasizes several key strategies. Promoting a positive group atmosphere, where members feel valued and respected, fosters cohesion and productivity. Strengthening leadership by involving members in decision-making and addressing their concerns can improve engagement and motivation. Enhancing cohesiveness through mutual support and shared goals strengthens group bonds, while effective communication ensures smooth information exchange and collaboration. Encouraging active participation in meetings and activities boosts group dynamics, and regular monitoring and support for these elements can drive continuous improvement. Implementing these strategies will improve group performance, member satisfaction, and overall success.

Conclusion

Understanding group dynamics is a game-changer for CBOs. Encouraging teamwork and open communication allows CBOs to access a variety of ideas and skills, leading to creative solutions, better decisions, and greater efficiency. Positive dynamics also create a welcoming environment that attracts and retains members, strengthening the organization's connection to the community. In the end, strong group dynamics help CBOs adapt and thrive, enabling them to make a lasting, positive impact.

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Article ID : 04/XII/15/1224

GENDER MAINSTREAMING IN AGRICULTURE

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Abstract

Gender mainstreaming is a process of ensuring that gender perspectives and attention to the issue of gender inequality in society are at the core of all policies, programme and project developments and implementation. It is important for active engagement of women in the processes of agricultural invention and innovation. Within an Institution, Gender Mainstreaming entails conducting gender assumptions at all levels of planning and implementation including the use of gender analysis, gender oriented capacity building and gender sensitive extension services. Gender sensitive policies include guidelines and plans that provide for gender needs and benefits in all programs and projects, and the data collection, such as sex-disaggregated statistical data in support of evidence-based policy. Moreover, Infrastructure such as childcare services and improved market access also plays a major role in gender mainstreaming in agriculture. Supporting campaigns for gender equality and the formation of women's agricultural groups, which increases their possibilities to be heard, and to initiates changes in the system. Therefore, gender mainstreaming fosters gender equality in the agricultural sector which enhances sustainable development and diminishes poverty.

Keyword: Gender mainstreaming, Agricultural innovation, Women empowerment, Sustainable development

Introduction

Gender mainstreaming is a strategy fairly new to many countries, including the United States. Gender mainstreaming is incorporated into all the policies and actions from the project cycle, which enhances the necessity of assessing the potential impacts of any intervention approaches on both females and males, to promote the equal sharing of benefits across all gender categories. It encourages the equal treatment of women and men, their needs and their experiences in order to advance development and combat discrimination. It is also a means of promoting social justice and equity. Addressing the issue of gender inequality in agriculture and women's empowerment for sustainable development in the rural areas of any country, including Nigeria, is especially gender-inclusive innovation strategy. Gender mainstreaming in agricultural innovation is a critical strategy for promoting gender equality and concerns gender and development in rural areas. Women can be empowered, agriculture can be made more productive and poverty can be reduced when all the stages of the gender involved innovation process including development and research, transfer and primary technology agricultural use and extension are well integrated. Gender analysis can highlight the needs, limitations, or opportunities in agriculture for women and men. Gender-responsive research and development also means that the integration of gender issues in development will be age appropriate for women and men. Comprehensive extension services can focus on support and training of women farmers.

Women can be empowered through improved access to finance and credit so that they invest in agricultural activities. They can also develop their lobbying ability by providing support to women's associations. Most importantly, appropriate laws and policies can be put in place which encourages women to engage actively in agriculture. With the outlined strategies, it is possible to develop a more fair and sustainable agriculture sector for both genders.

Need for gender mainstreaming

Organizational change

Developing a gender-responsive workplace is a multifaceted process aimed at transforming internal culture, developing appropriate policies, and most importantly the commitment of top management. First, it is important to create a gender repelling and gender neutral culture. This is because, every employee has to be treated fairly and respected without any bias. Along with this cultural change, it is important to have in place policies on the staff that address gender equity such as equal salary, allowing flexible work, and offering gender inclusive parental leaves in order to ensure practical measures of gender equity. Lastly, having all the leaders in the organization women or men who believe in gender equality strengthens such beliefs naturally from the highest level thereby giving the organization a firm outlook that goes round the organization.

Development operations

Gender perspectives needs to be introduced in development project in a way that is coherent and commences with gender analysis that reveals, what the project would do for, or against women and men, their needs, and their constraints and opportunities. This step is important because it guarantees that gender relations are taken into account when defining projects since it is critical in planning and carrying out projects for addressing the specific needs of each population group. Gender-sensitive planning and implementation follows, emphasizing the importance of specific and equitable solutions to the identified problems. To ensure these efforts achieve their stipulated impact, monitoring and evaluation processes must regulate gender-related outcomes and impacts, allowing for an assessment of the effectiveness of interventions and adjustments as needed. These processes combine creating the overall structure of the project.

Capacity building

Cumulatively, an approach to building gender capacity within any structure involves the training of personnel, provision of technical support and knowledge management. Training of personnel on gender issues helps the personnel to understand the issues in discharging their duties where gender integration is required. This is complemented by technical support which is intended to orient and enhance the use of gender specific activities, which means that there is an availability of support for staff as they try to use this research in practice. Encouraging knowledge sharing and learning among practitioners helps to share knowledge and experiences which in turn support the practice of gender mainstreaming and leads to advancement in all projects or cases.

Accountability mechanisms

In order to guarantee the success of gender mainstreaming undertakings, it is vital to have effective monitoring, reporting, and accountability systems in place. The absence of such a policy framework exposes organizations to the risk of implementing gende;ou non-focus effort and fail to monitor and evaluate the existing gender integration activities. Progress reports and evaluations of gender interventions help to address the question of the effectiveness of the interventions and informs on the next steps. External advances and setbacks are communicated to the appropriate parties through timely gender progress and outcome reporting. Not only this, but the very principle of accountability that individuals and organizations must deliver on gender equality enhances the need for such initiatives and propels progress in gender equity at all levels towards tangible results. All these ingredients comprise a structure that guarantees the evolution and the integrity of the gender integration policy as well.

Addressing resistance and challenges

Gender mainstreaming is rarely achieved with ease, as it is often necessary to deal with opposition, build alliances, and actively advocate for the cause. Understanding the dynamics of resistance is only the first step in addressing the challenge. All reasons for opposition must be explored, including ignorance, the insecurity about change, lack of facilities, and other internal structures, and individual measures must be devised to counter these impediments in order to encourage the promotion of gender issues. Collaborating with civil society organizations, government agencies, and other entities ensures that gender equality initiatives are not only widespread but also meaningful, thus fostering an inclusive strategy that pools together resources and knowledge for maximum effect. Policy implementation based on gender equity orientations and principles at all levels, including national and international, is also undertaken through advocacy and lobbying, which are key to the argument for systemic change and making gender equity central in all other issues. These strategies consolidate the bedrock pillars for long-term advancement of gender mainstreaming.

Objectives of gender mainstreaming

Achieve gender equality: In consideration of this objective, every person will be viewed as having the same opportunities, rights and responsibilities irrespective of their gender, without ensuring the existence of inequalities and encouraging creation of a balanced society.

Gender mainstreaming: The process of integrating gender into the development of policies, programs and projects as well as during implementation, monitoring and evaluation of all these activities.

Remove gender stereotypes: To recognize, reduce and challenge gender biased institutional practices and societal norms while encouraging respect towards all people irrespective of their gender.

Ensure equitable access to resources: To preserve and also to improve the state of education, health care, employment, political participation and other available resources to the population, proportionately to all genders without overlooking their differences.

Promote sustainable development: To support sustainable development, irrespective of gender, by empowering the contributions of all individuals, thus, advancing economic, social, and environmental well-being.

How to achieve gender mainstreaming in agriculture

Policy integration: Inclusion of issues related to women into the context of Agricultural Policies and Programs. Women make up a large proportion of the labor force in agriculture. Women use these policies to access resources and services such as training, equipment and marketing. In this way, women given policies enable both men and women to work with supportive systems within their jobs in the agricultural sector. These policies create gender aware and gender biased policies that aims enter the employment of either gender most appropriately in consideration of all the challenges and advantages.

Access to resources: While designing the policies that strengthen women's hands in agriculture, there is a need to ensure that the benefits they tend to enjoy are enlarged to include land, capital, technology, and in most cases time. The land ownership of women and tenure rights are facilitated through legal reforms and civic education which enables them to own and manage land which is very fundamental in their quest to be economically active. Moreover, increasing access of women to cash, credit, and other availabilities in financial services relates to better agricultural practices and economic coping strategies. It is also important to provide women with agricultural implements, technology, inputs such as seeds and fertilizers as this encourages them to participate meaningfully in the sector which enhances individual and community wellbeing.

Capacity building: To successfully address the constraints faced by women farmers, it is imperative to provide appropriate training programs and adaptable extension services. Training programs which are geared to women farmers in terms of skill acquisition and leadership programs are effective in enhancing women farmers as they respond to specific challenges. Apart from that, there is also the need to diversify agricultural extension services so that it can include women who are able to access the information as well as their resources. The training of more women extension workers will serve the purpose of increasing coverage and creating an enabling atmosphere for women's participation in agriculture and leadership in the community. One outcome of these measures is to create the basis for fair growth of the sector.

Data collection and research: Gender equality promotion in agricultural development begins with the availability of gender-sensitive approaches and harnessing gender-based research. Data collection and integration methods help explore the roles, challenges, as well as contributions of both men and women involved in the sector making it easier to understand their requirements. Investigating gender concerns in the agricultural settings promotes policy or strategies on gender equality as well as makes sure that good practices are based on facts that everyone encounters. All these make it possible to have a more stratified and productive agricultural system that reaches out to all the people in the system.

Supportive infrastructure: It is imperative that women farmers receive appropriate support by providing services such as child care and other social amenities to ease the reproductive work burden if these women are to be fully engaged in agriculture. There is also a need to invest in improved means of transport and marketing infrastructure for female farmers for ease of selling their produce which will in turn improve their economic status and relevance in the agriculture sector. Thus, by tackling both sides of the burden, charge and difficulty of women in accessing markets, these strategies are able to create a scenario that enables women and improves their input towards agricultural production.

Awareness and advocacy: Involving both male and female individuals in community conversations and awareness initiatives is fundamental to altering mindsets and combatting the stereotypes attributed to gender roles in agriculture. Encouraging participation in such programs widens the lens of gender equity in farming beyond just the men and women. Agricultural cooperatives and advocacy groups of women are encouraged and supported as this helps in the cultivation of concerns related to women. The approach serves to enhance their power or ability to effect some changes, but, more importantly, to gain control over resources and participate in the management of agriculture in a way that supports them as women and as gender equals.

Conclusion

As a final point, it is undeniable that gender mainstreaming is an important approach in the promotion of gender equality in agriculture. Bringing gender issues into policies or projects helps to avert or decrease gender exclusions, in which few men or women benefit. Women farmers can become more productive in agriculture when sensitized Extension Services and Inputs are complemented with access to land, finance, and technology for women farmers. In addition, strategies to support gender equality such as infrastructure, advocacy and policy involve significant investment in agricultural sector equity. Gender mainstreaming redresses gender an inequality which in turn leads to sustainable development, alleviation of poverty and improvement of the economic wellbeing of the region.

Conflict of interest : Authors declare no conflicts of interest.

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ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 04/XII/16/1224

BACTERIAL WILT DISEASE: AN OVERVIEW

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Overview of Bacterial Wilt

Bacterial wilt a devastating disease caused by *Ralstonia solanacearum* is a highly adaptable pathogen first identified by E.F. Smith in 1896 in crops like tomato, eggplant, and potato. Since then its host range has expanded to over 200 species. This pathogen significantly affects crop productivity worldwide.

The Pathogen: *Ralstonia solanacearum*

R. solanacearum is a complex bacterial species characterized by high genetic diversity and pathogenicity. It survives in soil, water and plant debris and invades hosts through wounds or natural root openings. Once inside it multiplies moves through the xylem and obstructs water flow causing symptoms like wilting, necrosis and plant death. The pathogen secretes enzymes and exopolysaccharides (EPS) that degrade host tissues and facilitate colonization.

Host range and disease symptoms

This pathogen has a vast host range, infecting key crops such as tomato, potato, banana, tobacco and ginger. Symptoms includes:

- **External:** Early "green wilt," followed by yellowing and browning of leaves, eventually leading to plant collapse.
- **Internal:** Discoloration and necrosis of vascular tissues; slimy, viscous ooze from cut stems due to bacterial exudates. These symptoms distinguish bacterial wilt from other diseases like *Fusarium* yellows.

Pathogen survival and infection cycle

R. solanacearum persists in soil, water and alternative host plants, often as a latent infection. It enters root tissues via wounds, colonizes intercellular spaces and invades xylem vessels moving upward and obstructing water transport. The pathogen's life cycle includes overwintering in soil or plant debris aided by its ability to adapt to varying environmental conditions.

Host-pathogen interaction

The interaction occurs in three phases:

1. **Root Colonization:** Pathogen attaches to weaker root zones, aided by flagella and pili.
2. **Cortical Infection:** Bacteria proliferate in the cortex degrading tissues with enzymes.
3. **Xylem Invasion:** Pathogen breaches the endodermis and enters xylem spreading systemically and releasing toxins.

Environmental reservoirs and weed hosts

Reservoir plants and weeds like *Solanum dulcamara* and *Solanum nigrum* harbor *R. solanacearum* as latent infections aiding its persistence in the ecosystem. The pathogen's release from infected plants into soil and water facilitates further spread.

Defence mechanisms and disease variation

Resistance in some hosts limits pathogen spread through defence responses including tyloses formation and phenolic compound production. Susceptibility varies based on pathogen aggressiveness host defence capacity and environmental conditions. This interplay of biological and environmental factors underscores the need for integrated management strategies to mitigate bacterial wilt's impact.

The role of biotic and abiotic factors in bacterial wilt disease development

Bacterial wilt, pathogen *Ralstonia solanacearum* development and spread are influenced by a complex interaction of biotic (living) and abiotic (non-living) factors. These factors shape the pathogen's survival, virulence and interactions with the host and surrounding environment making disease management a significant challenge.

Biotic Factors

Pathogen variability and virulence

R. solanacearum is a genetically diverse pathogen comprising different races, biovars, and strains with varying levels of aggressiveness. This diversity enhances the pathogen's adaptability to different hosts and environments. Studies have shown that certain strains of *R. solanacearum* are highly virulent, capable of infecting a wide range of hosts, including ginger under favourable conditions. Such strain variability complicates disease management, as control measures effective against one strain may not work against others.

Host susceptibility

Most commercially cultivated crop varieties are highly susceptible to *R. solanacearum*. Host resistance plays a critical role in disease progression yet few varieties exhibit strong resistance. Research has suggested that physiological factors, such as plant age, growth stage and overall health significantly influence the host's susceptibility to infection. Pathogen entry is facilitated by wounds or natural openings in the root system making stressed plants more vulnerable.

Rhizosphere microbiome

The rhizosphere, the zone surrounding plant roots, is a dynamic hub of microbial activity. Beneficial microbes in this zone can suppress *R. solanacearum* through competitive exclusion, production of antimicrobial compounds, and induction of host systemic resistance. However, factors like soil management practices and pesticide use can disrupt the rhizosphere microbiome, reducing its ability to counteract pathogen invasion. Emerging research highlights the potential of biocontrol agents, such as *Pseudomonas* and *Bacillus* species, to enhance rhizosphere resilience against bacterial wilt

Abiotic factors

Soil conditions

Soil properties significantly influence the survival and activity of *R. solanacearum*. The pathogen thrives in acidic soils with high organic matter content, which can promote bacterial survival and colonization. Soil texture also plays a role, with heavier clay soils retaining more moisture and creating favourable conditions for pathogen persistence. Conversely sandy soils with lower water retention are less conducive to bacterial survival.

Moisture levels

Soil moisture is one of the most critical abiotic factors driving bacterial wilt dynamics. Excessive soil moisture or waterlogging enhances the motility and spread of *R. solanacearum* through soil and plant tissues. High moisture levels also reduce oxygen availability in the root zone stressing plants and making them more susceptible to infection. Conversely well-drained soils with optimal irrigation can help minimize disease incidence.

Temperature

The activity of *R. solanacearum* is highly temperature-dependent. The pathogen's optimal growth and infection range is between 25°C and 35°C, with warmer temperatures accelerating bacterial multiplication and infection rates. Temperature fluctuations outside this range can suppress pathogen activity, which explains the seasonal variability in bacterial wilt outbreaks. Tropical and subtropical regions, characterized by consistently high temperatures and humidity, provide ideal conditions for disease proliferation.

Farming practices

Abiotic factors are also influenced by farming practices. Over-irrigation, monocropping, and inappropriate soil amendments can create conditions conducive to bacterial wilt development. On the other hand, practices like crop rotation use of organic amendments and maintaining proper drainage can mitigate the risk of disease by influencing soil properties and microbial dynamics.

Integrated Disease Management Strategies

Given the interplay of biotic and abiotic factors, an integrated approach is essential for managing bacterial wilt disease. Key strategies include:

- **Breeding for Resistance**: Developing and promoting resistant varieties tailored to specific regions and strains of *R. solanacearum*.
- **Biocontrol Agents**: Leveraging beneficial microbes, such as *Trichoderma* and *Pseudomonas*, to enhance soil health and suppress pathogen activity.
- **Optimized Irrigation**: Implementing precise irrigation strategies to avoid waterlogging while maintaining adequate soil moisture levels.
- **Soil Health Management**: Improving soil properties through organic amendments, crop rotation, and proper fertilization practices.
- **Surveillance and Monitoring**: Utilizing molecular tools to track pathogen populations, assess soil microbial diversity, and predict disease outbreaks based on environmental conditions.

Future Directions

While significant progress has been made in understanding bacterial wilt, gaps remain in translating this knowledge into practical solutions. Advances in metagenomics and bioinformatics offer new opportunities to decode the complex interactions between *R. solanacearum*, the rhizosphere microbiome, and environmental factors. Future research should focus on identifying microbial communities and genes associated with disease suppression tailoring management practices to local agroecological conditions, and developing climate-resilient varieties. By addressing these challenges, it will be possible to reduce the economic losses caused by bacterial wilt and ensure sustainable crop production in regions prone to this devastating disease.

Conclusion

Bacterial wilt caused by *Ralstonia solanacearum* remains a critical threat to many crops worldwide, largely due to the pathogen's high adaptability, extensive host range, and complex survival strategies. It thrives in diverse environments, persists in soil and water reservoirs, and utilizes alternate host plants and weeds to sustain its life cycle. Symptoms such as wilting, vascular discoloration, and bacterial exudation are hallmarks of the disease, severely impacting plant health and yield. Understanding the pathogen's interaction with its host, from root colonization to xylem invasion highlights the challenges in managing this disease. Variability in host susceptibility and pathogen virulence, compounded by environmental conditions, underscores the importance of tailored, integrated management strategies. These include breeding for resistant varieties, employing biocontrol agents, and optimizing agricultural practices to mitigate disease spread and severity. By combining advancements in pathogen biology, host resistance, and ecological management, it is possible to reduce the burden of bacterial wilt and support sustainable production.

ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/17/1224

DIAGNOSIS AND IMPROVEMENT OF PHOSPHORUS DEFICIENCY IN CROPS

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Phosphorus (P) is an essential nutrient required for plant growth. It is the second most limiting macronutrient after nitrogen (N). Inadequate P nutrition delays plant maturity and reduces yields. The right balance of phosphorus is vital to plant health. Learn deficiency symptoms, tissue sufficiency ranges, and common phosphorus sources.

Functions of Phosphorus in Plants

Phosphorus is an essential nutrient, as a part of key plant structure compounds and as a catalysis in the conversion of numerous key biochemical reactions in plants. Phosphorus in plants is key in capturing, storing, and converting the sun's energy into biomolecules, such as adenosine triphosphate (ATP), that drive biochemical reactions (e.g., photosynthesis) from germination through the formation of grain to maturity. Phosphorus is present in deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), which store information on how plants should perform routine functions such as synthesizing proteins, lipids, and nucleic acid and metabolizing sugars. Phosphorus promotes early root growth, winter hardiness, and seed formation, stimulates tillering, and increases water use efficiency. Phosphorus roles in plants are summarised below:

- Enables photosynthesis (energy transformation)
- Builds nucleic acids, proteins and enzyme
- Facilitates root growth
- Strengthens stems and stalks
- Improves flower formation and seed production
- Promotes crop uniformity
- Contributes to earlier maturity
- Increases disease resistance
- Improves overall crop quality

Phosphorus Deficiency Symptoms in Plants

- **Stunted Growth:** Plants deficient in phosphorus often exhibit reduced growth, resulting in shorter stems and smaller leaves.
- **Dark Green or Purplish Leaves:** Phosphorus-deficient plants may have leaves that appear dark green or develop a purplish tint, especially on the underside of the leaves.
- **Delayed Flowering:** Phosphorus deficiency can delay flowering in many plants, which can affect fruit and seed production.
- **Reduced Fruit and Seed Production:** Phosphorus deficiency can lead to fewer and smaller fruits or seeds. In some cases, fruits may have poor colouration or flavor.
- **Poor Root Development:** Phosphorus is crucial for root development. Deficient plants may have poorly developed and shallow root systems, which can make them more susceptible to drought stress.

- **Leaf Necrosis:** In severe cases, phosphorus deficiency can lead to the death of older leaves, which may develop necrotic (dead) spots or edges.

Plants generally turn dark green (both leaves and stems) and appear stunted. Older leaves are affected first and may acquire a purplish discolouration. In some cases, leaf tips will brown and die appear weak and maturity is delayed.

Phosphorus deficiency in plants can be visually identified at the early vegetative stage as an abnormally dark green or reddish purple colour along the edge of the lower plant leaves. Deficiency may be observed even in high phosphorus soils, during cold temperatures, especially in winter season. Cold temperatures retard root growth and reduce the phosphorus uptake in plants. Symptoms diminish, however, as the soil warms up. Factors such as soil compaction, herbicide injury, insect pressure, and poor soil health also can cause phosphorus deficiency. The classic P deficiency symptoms and their descriptions for several major crops are being given here.

Maize: Inadequate P may result in dark green plants with reddish-purpletips and leaf margins. It is more likelyto appear on young plants, especiallyon soils that are cold, wet, or too dry.The purple colour does not necessarilysignal P deficiency, because that is thenormal appearance in some hybrids.Some hybrids may be deficient without obvious symptoms (**Photo 1**).

Photo 1. Phosphorus deficiency in Maize

Sorghum: Plants deficient inP appear stunted and may bespindly, with low vigor. Darkgreen leaves may also show dark red colour. Leaf tips andinterveinal tissue show red- ness that progresses toward the base, veinal tissue, and midrib. The entire leaf may become red. With more severe deficiency, leaves turnpale brown and die, and rootsmay turn dark and discoloured (**Photo 2**).

Photo 2. Phosphorus deficiency in Sorghum

Rice: Phosphorus deficiency does not always show adistinct purple colour in riceand other grass plants.Symptoms may be observedin seedling rice as severe stunting, small diameter stems, and lack of tillering.The dark green colour of deficient leaves can vary to lightgreen or yellow, lighter leafcolours being associated withcool temperatures (**Photo 3**).

Photo 3. Phosphorus deficiency in Rice

Wheat:

Plants are smaller and weaker than normal, leaves and stems develop a purple tint, especially on the middle of older leaves, leaf tips may die back, especially in severe cases, plants exhibit poor tillering, stems are thin and shortened, plants mature more slowly, seedlings appear pale olive green and wilted, chlorosis starts at the tip of older leaves, leaves are dull dark green with slight mottling of the oldest leaf, plants look unusually water-stressed (**Photo 4**).

Photo 4. Phosphorus deficiency in Wheat

Lentil : Delayed emergence, plants are stunted with thin stems and roots, leaves may be red, purple, or matte, may drop, starting with the oldest leaves. There may be reduced nodulation, and flowers may abort resulting low yield (**Photo 4**).

Photo 4. Phosphorus deficiency in Lentil

Soybeans: Phosphorus is required for normal fixation ofnitrogen (N) in soybeans. Relatively large amounts of P are needed, especially at podset. Uptake of P may be reduced in cool, wet soils; deficiency symptoms are notalways clear. Leaves may turndark green or bluish green, and the leaf blade may curl up and appear pointed. Phosphorus deficiency can delay blooming and maturity (**Photo 5**).

Photo 5. Phosphorus deficiency in Soybeans

Mustard: Phosphorus deficiency restricts root and top growth in canola. Mildly deficient plants are small, but appear normal. With more severe deficiency, the root system is poorly developed and stems are thin and erect with few branches and small, narrow leaves. Leaves and stems may develop a purplish discoloration, or leaves may become a dark bluish-green (**Photo 6**).

Photo 6. Phosphorus deficiency in Mustard

Cotton: Deficient plants may be stunted, with leaves darker green than normal. Flowering may be delayed and boll retention poor. Premature senescence of leavesmay occur on P-deficient plants later in the season. Deficiency doesnot usually occur in early growth ofcotton (**Photo7**).

Photo 7. Phosphorus deficiency in Cotton

Sugarcane: Because P is mobile in the plant, deficiencyusually occurs first in older tis-sues. Distinct symptoms are not always obvious. The maineffect of deficiency is retardedgrowth. Older leaves may turnyellow and eventually die backfrom tips and along margins (**Photo 8**).

Photo 8. Phosphorus deficiency in Sugarcane

Egyptian Clover (Berseem): Symptoms of P deficiency in alfalfa may include dark green or purplish leaves, with tip death in some cases. Upward tilting of leaflets and stunted growth may occur. Reduced nodulation and increased winterkill may be other consequences. Alfalfa plants deficient in P may appear water stressed. The photo at left above shows alfalfa in a plot fertilized with P. The photo at rightabove shows severe P deficiency in Egyptian Clover (**Photo 9**).

Photo 9. Phosphorus deficiency in Egyptian Clover (Berseem**)**

Potato: Stunted growthand dark green colour may besigns of P deficiency. Leaf roll and upward cupping ofleaf blades sometimes occuras severity of deficiency increases (**Photo 10**). Symptoms are more likely when soil temperatures are relatively low. Phosphorus deficiency ismore frequent on acid and calcareous soils or onkaolinitic soils.

Photo 10**.** Phosphorus deficiency in Potato (Even a severe P deficiency in a potato leaf shows no sign of red or purple margins – but the whole leaf may turn a deep bluish green)

Sweet Potato: Older leaves die before they should. Yellowing may start in patches between the veins, or it may be more general and affect one side of the leaf more than the other. Chlorotic areas may appear orange or red due to anthocyanin pigments. Other symptoms of phosphorus deficiency in plants include: stunted growth, dark green leaves and stems, purple discoloration of older leaves, browned and dying leaf tips, and delayed maturity (**Photo 11**).

Photo 11**.** Phosphorus deficiency in Sweet Potato

Tomato: Leaves and stems may develop a purplish discolouration, or leaves may become a dark bluish-green (**Photo 12**).

Photo 12. Phosphorus deficiency in Tomato (Purpling of leaf, Left) and extreme purpling on the underside of a leaf. (Right)

Lettuce: The plant appears darker green overall. The plant's growth is reduced, affecting the size of the leaves and thickness of the stem. The older leaves develop irregular spots of brown to dark brown dead tissue. The leaf margins, older leaves, or stems may develop a purplish or red pigmentation (**Photo 13**). Older leaves develop paper-like necrotic areas and eventually die off. The roots may show reddish discoloration. The plant's maturity is delayed and also the yield.

Photo 13. Phosphorus deficiency in Lettuce

Grapes: Deficiency of P has not beena widespread problem in vineyards. Where symptoms have been observed, they are variable dependingon variety. In white varieties the primary and secondary veins remain green while the interveinal tissuebecomes chlorotic. Symptoms first appear on the leaf margin. In red grapes interveinal tissue yellows and turns red, producing islands of red tis- sue surrounded by yellow-green veins (**Photo 14**). Few grapes clustersform per vine, are small with poor set, and shot berries.

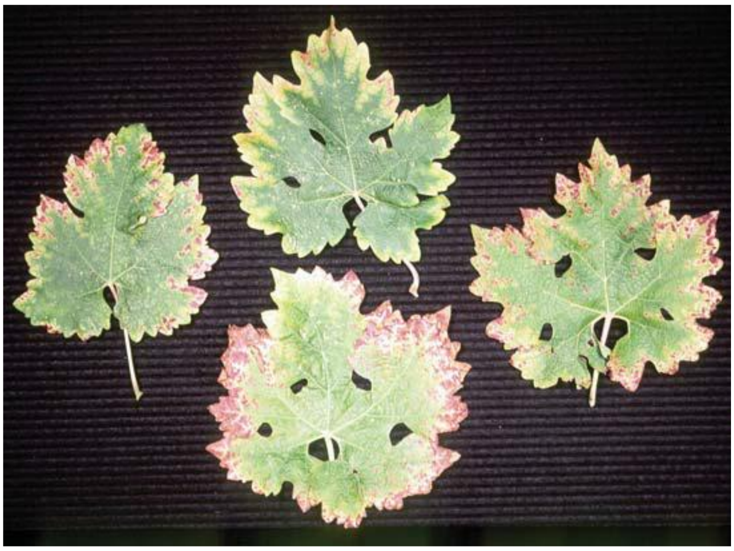

Photo 14. Phosphorus deficiency in Grapes

Guava: Older leaves may appear dark or blue-green in colour. In severe cases, leaves and stems may turn purple (**Photo 15**). The plant may grow slowly, weakly, and be stunted. The plant may mature more slowly and produce poor quality fruit and seeds. Older leaves may be smaller than normal and they curl and distort. Leaf veins may appear unusually purple and leaf tips may become brown and finally they die (Better Crops, IPNI, 3013). http://ipni.info/nutrientimagecollection).

Photo 15. Phosphorus deficiency in Guava

The anthocyanins associated with P deficiency are usually red to purple. In some species, including corn, apples, pears, and strawberries, symptoms are most prominent on leaf margins. Experiments with apples have shown that when a P deficiency is relieved, the red/purple colour of the leaf margins subsides. In other species, for example tomatoes, the undersides between the veins turn purple. Other species—like sugar beet, rice, potato, and onions—don't change colour at all, other than perhaps a deepening of greenness as the plant's growth is stunted. Chlorophyll contains no P, so in a deficient plant, chlorophyll may have higher abundance relative to P-containing compounds.

Managing Phosphorus Deficiency

- **Soil Testing:** Start by conducting a soil test to determine the extent of phosphorus deficiency in your horticultural area. This will help you determine the appropriate corrective measures.
- **Phosphorus Fertilisation:** Correct phosphorus deficiency by applying phosphorus-containing fertilisers. The choice of fertiliser depends on the soil pH and the specific needs of the plants.
- **Fertiliser Application Timing:** Apply phosphorus-containing fertilisers at the right time. Phosphorus is less mobile in the soil than some other nutrients, so it's essential to apply it before or during planting to ensure it's available when the plants need it.
- **pH Adjustment:** Check and adjust the soil pH if it's too high or too low. Phosphorus availability is influenced by soil pH. In alkaline soils, phosphorus becomes less available, so lowering the pH may help.
- **Organic Matter:** Improve soil fertility and phosphorus availability by incorporating organic matter such as compost or well-rotted manure into the soil. Organic matter can also help improve soil structure and water-holding capacity.
- **Crop Rotation:** Practicing crop rotation can help prevent the depletion of phosphorus in the soil, as different crops have varying nutrient requirements.
- **Avoid Overuse:** While addressing phosphorus deficiency is important, it's equally important not to overapply phosphorus fertilisers, as excessive phosphorus can lead to environmental issues like water pollution and negative interactions with micronutrients.

Correction and prevention of phosphorus deficiency typically involves increasing the levels of available phosphorus into the soil. Planters add phosphorus into soil with manures, and phosphate-fertilizers. Introducing these compounds into soil however, does not ensure the alleviation of phosphorus deficiency. There must be phosphorus in the soil, but the plant must also absorb the phosphorus. Phosphorus uptake is limited by the chemical form of the phosphorus. A large portion of phosphorus in soil is in chemical compounds that plants can't absorb. Phosphorus must be present in soil in specific chemical arrangements to be usable as plant nutrients. Facilitation of usable phosphorus in soil can be optimized by maintaining soil within a specified pH range. Soil acidity, measured on the pH scale, partly dictates what chemical arrangements that phosphorus forms. Between pH 6 and 7, phosphorus makes the fewest bonds which render the nutrient unusable to plants. At this range of acidity, the likeliness of phosphorus uptake is increased and the likeliness of phosphorus deficiency is decreased. Another part of prevention and treatment of phosphorus is the plant's disposition to absorb nutrients. Plant species and different plants within a species react differently to low levels of phosphorus in soil. Greater expansion of root systems generally correlates to greater nutrient uptake. Plants within a species that have larger roots are genetically advantaged and less prone to phosphorus deficiency. These plants can be cultivated and bred as a long term phosphorus deficiency prevention method. Along with root size, other root adaptations to low phosphorus, such as mycorrhizal symbioses, have been found to increase nutrient intake. These adaptations to roots work to maintain levels of vital nutrients. In larger commercial agriculture settings, variation of plants to adopt these desirable phosphorus intake adaptations may be a long-term phosphorus deficiency correction method.

ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/18/1224

DOUBLING FARMER'S INCOME: STORY OF SUCCESSFUL CASES FROM THE HIMALAYAN REGION OF WEST BENGAL

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Introduction

The project on Doubling Farmers' Income (DFI) is a comprehensive initiative by the Indian Council of Agricultural Research (Chand, 2017) aimed at increasing farmers' incomes through sustainable and modern agricultural practices (Muhie, 2022). In this chapter we are sharing the success story of farmers, namely Mira Tamang, Gyanendra Rai, Nandalal Niroula and Mahendra Chettri. It will cover the farmers' cultivation details from pre-intervention and post-intervention, made by ICAR – IARI, Regional Station, Kalimpong India, under DFI intervention and how these approaches built significant contributions, playing a major role in their income and success. It focuses on promoting advanced farming techniques, efficient resource management, market linkages, and diversification into allied activities like animal husbandry and agro-based industries (Unjia*et al.,* 2024). Through research, capacity-building, and policy support, the project seeks to empower farmers and create a resilient agricultural sector (Chary *et al.,* 2022).

Case Study I:

This is a story of a 53-year-old woman, Mrs. Mira Tamang, lives in a village of Mungpoo, Darjeeling district of West Bengal. She lives in a small village of Mungpoo near Chowrasta, situated 40 Km from Siliguri, West Bengal. Like other women in her village, Mrs. Mira Tamang was a simple homemaker who spent her whole life taking care of family members. However, she was searching for an occupation which she could do after attending all the family duties and responsibilities. She always wanted to support her family through some additional income. Before the DFI intervention, she was engaged in orange cultivation, nutri-kitchen gardening and floriculture activities off-time to supplement her family income. Thus, she used to earn an annual income of Rs. 1,95,000 from orange, cabbage, orchid and ponsettia cultivation. She faced problems like low production, irrigation and marketing etc. and was dependent on her husband for any major financial need.Mira Tamang was of an inquisitive mind, innovative in nature and always loved to try something new in agriculture. Hence, she attended the different training progarmme of IARI and participated in cluster front line demonstration (CFLD) programme of IARI on following technologies- grafted mandarin cultivar of IARI-Kalimpong, large cardamom sucker of IARI-Kalimpong, Cabbage (Rare ball F1), Cauliflower (Candid charm F1), Coriander (Bliss), Chilli (LHC star), Kale (Pusa kale 6) and orchid cultivation.After attending IARI's DFI project workshop and training courses on Darjeeling mandarin cultivation, pest and disease management, grafting and budding technique, post harvest management, she became confident to start orange cultivation and followed a systematic scientific approach for establishing new orange orchards. She was one of the early farmers who planted 20 grafted Darjeeling orange on the unused land near to her home. She also adopted intercropping of vegetables of improved varieties with Darjeeling orange. Besides this, she learned the technique of grafting and budding for the project and started to prepare healthy grafted planting materials within the polyhouse constructed for the project. After two years, the plant started fruiting, and became confident that using grafted planting materials one farmer could get a return within 3–4 years. She started convincing other farmers and almost 100 farmers in Mungpoo, who had now re-started orange cultivation, seeing the success of Mira Tamang. Presently, her orchard is 5 years old, and she is earning approximately Rs. 1,60,000 with an annual production of 50 q orange from 0.5 acre orchard. The income from cabbage cultivation in 0.3 acre area has increased to Rs. 80,000 from Rs. 60,000 within a five-year period due to the adoption of improved high-yielding varieties of cabbage. During the same period, the production and income from orchids registered a growth of 70 percent and 60 percent respectively. The income from poinsettia has also risen by 60 percent. Thus, her total net income during the assessment period was Rs. 1,56,000 registering an increase of 213.06 percent. As a trainer, she also raised awareness and taught many other women in her village about Darjeeling orange cultivation, which led to the cascading effect of increasing their monthly earnings. Mira Tamang says, "I had never dreamt that I would not only build my skills on what I used to love, but also give a nutritional touch to the food. I was happy to contribute to bringing the disappearing but most delicious orange of this Himalyan region back to the agricultural landscape". Now she has mastered the art of grafting and budding technique, and raisinga number of grafted planting materials for selling to interested farmers. From being a trainee to becoming a master trainer has brought immense joy, satisfaction and pride to her. With her hard work, zeal and determination, Mira Tamang's earnings have skyrocketed to `approximately Rs.25,000 per month, enabling her to become financially independent and have a better lifestyle for her family. She has developed the confidence to voice her opinion and contribute to the decision-making process in her family, in the village and in her city. She has become truly 'atmanirbhar' and brand ambassador in her village by doubling her income through farming activity.

Table 1: Increase in production and income of beneficiary under DFI

Crop names	Benchmark (Baseline period 2018-19)				Post-intervention period (2022-23)				% increase over base year	
	Area (Acre)/ No.	Production (Q/Liter /No.)	Gross Income (Rs.)	Net Income (Rs.)	Area (Acre) / No.	Production	Gross Income	Net Income (Rs.)	Production	Income
Orange	0.5	30 q	100000	40000	0.5	55 q	160000	90000	45.45	55.56
Cabbage	0.3	50 q	60000	25000	0.3	65 q	80000	40000	23.07	37.50
Orchid	0.1	600	25000	10000	0.2	2000	40000	16000	70	60
Poinsettia	0.1	1000	10000	4000	0.2	3000	30000	10000	66.67	60
Total	0.82	53/1600	195000	79000	0.84	110/5000	310000	156000	205.19	213.06


Fig.1: Attending training on mandarin cultivation


Fig.2: Raising grafted mandarin seedlings

Case Study II:

Gyanendra Rai (Age-38) is a resident of Village Samabeong Tindhurey in the Kalimpong district of West Bengal. After completion of Higher secondary education, he started farming in a 5 acre area to support his family. Out of the total area, only 2.05 acres of land was used for crop cultivation and the rest of the land was unutilized. Before the DFI intervention of IARI, he was mainly cultivating field crops like large cardamom in a 2 acre area, ginger in a 0.05 acre area and was rearing 2 cows. He was following traditional technologies and practices to grow large cardamom and ginger. The total production of Large Cardamom was 20 quintals from a 2 acre area and 3 q ginger from a 0.05 acre area. He used to get 6 l of milk daily from his 2 cows. His gross income from farming was Rs. 10,40,000 and net income was Rs.4,26,000. During this period, he was facing problems, like low production of crops, infestation by viral diseases and having an irrigation water crisis. Hence, he attended the different cluster front line demonstration (CFLD) programme of IARI on major crops, like- Pm-26 and PM-28 variety of mustard, large cardamom sucker of IARI-Kalimpong, grafted mandarin cultivar of IARI-Kalimpong, red cabbage (red jewel),Cabbage (Rare ball F1), Cauliflower (Candid charm F1), Coriander (Bliss), Chilli (LHC star), Kale (Pusa kale 6), ginger and orchid cultivation. After the intervention of DFI, he adopted recommended cultivars of large cradamom, healthy suckers, pest and disease management strategies, fertilizer management strategies and post-harvest practices for better production and income. Following the advisory services, he was able to generate more production and income from the same farming activity. Now he has produced 40 q large cardamom from a 3 acre area with a gross income of Rs.28,00,000 and a net income of Rs.10,0,000. The IARI regional station Kalimpong demonstrated an improved cabbage variety like early drum head and introduced the red jewel of the red cabbage variety. As a result, he could generate additional net income of Rs. 40,000 from the 0.05 acre area. The adoption of an improved breed of cow helped to increase milk production. Now he got 10 l of milk daily from his 3 cows and his net income by selling milk was Rs.30,000 per year. Thus, his total gross income and net income in 2022-23 was Rs.29,30,000 and Rs. 10,70,000 with were a 213.33 percentage increase in net income.

Table 2: Increase in production and income of beneficiary under DFI

Crop names	Benchmark (Baseline period 2018-19)				Post-intervention period (2022-23)				% increase over base year	
	Area (Acre)/ No.	Production (Q/Liter /No.)	Gross Income (Rs.)	Net Income (Rs.)	Area (Acre) / No.	Production	Gross Income	Net Income (Rs.)	Production	Income
Large cardamom	2	20 q	10,00000	400000	3	40 q	2800000	1000000	50	60
Ginger	0.05	3 q	10000	6000	0.05	3.5 q	13500	7500	14.28	20
Cow	2.	6 l/day	30000	20000	3	10 l/day	50000	30000	40	33.33
Red cabbage	-	-	-	-	0.5	70 q	80000	40000	100	100
Total	2.05/02	23/6	1040000	426000	3.50/3	110/10	2930000	1070000	204.28	213.33

ISSN : 2583-0910
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Fig.3: Infested large cardamom fields of Mr. Gyanendra Rai

Fig.4: Attending training on large cardamom

Case Study III:

This is another successful case of doubling a farmer's income by Nandalal Niroula (Age-75) of Lower Iche Thapa Gaon in the Kalimpong district of West Bengal. He completed his school education (class-X) from a village school and started farming activities since childhood to support the family economy. He has a land holding size of 5 acres with limited access to water and surrounded by forest and deep hills. From this, only 2.71 acres of land was used for crop cultivation. Before the DFI intervention, he was cultivating field crops, horticulture crops and flowers, namely Paddy (1 acre), Large Cardamom (1 acre), Orange (0.3 acre), Mustard (0.4 acre) and Agellia (0.01 acre). But the average productivity of all the crops was very low. He could produce only 15 q paddy from a 1 acre area, 10 q large cardamom from a 1 acre area, 20 q orange from a 0.3 acre area, 2.5 q mustard from a 0.4 acre area and 20,000 agellia seedlings in his farmyard. From this, he could generate a gross income of Rs. 6,40,750 and net income of Rs.2,73,000, which was not sufficient to fulfill his family needs. Further, he was plagued with multiple problems, like the decline of orange orchards due to pests & diseases infestations, a viral and fungal attack in a large cardamom field and the marketing of flowing plant and agri-produce. After the participation in DFI intervention of IARI regional station, Kalimpong, he was introduced to new crops and varieties, like improved paddy variety (PS-5, Pusa 1612, Pusa 1509), mustard (PM26, PM-30), tomato (Pusa rohini), cow pea (Pusa Sukamal),cabbage (Red jewel, Rare ball F1), cauliflower (Valentia, Pusa hybrid 2), green gram (Pusa Vishal), Arhar (Pusa 991), healthy suckers of large cardamom, and grafted healthy seedling of Darjeeling mandarin and floriculture. Besides this, he participated in numerous training programmes on crop production technologies, pest and disease management and nutrient management of all the crops. This helps to bring revolutionary change in production and productivity of all the major crops. Now, he is able to produce 25 q paddy, 20 q large cardamom, 40 q orange, 3.2 q mustard and 2,500 agellia seedlings from the same area. Presently, its gross income was Rs.10,76,000 Rs and net income was Rs.4,72,000, registering a 181.88 percent increase in production and a 204.72 percent increase in net income from the same area of land. The initiative of DFI helped in miltiple ways in this endeavour.

Table 3: Increase in production and income of beneficiary under DFI

Crop names	Benchmark (Baseline period 2018-19)				Post-intervention period (2022-23)				% increase over base year	
	Area (Acre)/ No.	Production (Q/Liter /No.)	Gross Income (Rs.)	Net Income (Rs.)	Area (Acre) / No.	Producti on	Gross Income	Net Income (Rs.)	Produ ction	Income
Paddy	1	15 q	22000	14000	1	25 q	45000	25000	40	44
Large Cardamo m	1	10 q	500000	200000	1	20 q	800000	350000	50	42.86

Crop names	Benchmark (Baseline period 2018-19)				Post-intervention period (2022-23)				% increase over base year	
	Area (Acre)/ No.	Production (Q/Liter /No.)	Gross Income (Rs.)	Net Income (Rs.)	Area (Acre) / No.	Production	Gross Income	Net Income (Rs.)	Production	Income
Orange	0.3	20 q	50000	25000	0.3	40 q	120000	50000	50	50
Mustard	0.4	2.5 q	8750	4000	0.4	3.2q	16000	7000	21.88	42.86
Agellia	0.01	2000	60000	30000	0.01	2500	95000	40000	20	25
	2.71	47.5/2000	640750	273000	2.71	88.2/2500	1076000	472000	181.88	204.72


Fig.5: Attending training on grafting of mandarin


Fig.6: CFLD of PS-5 variety of paddy

Case Study IV:

This is another success story of a struggling farmer, namely Mahendra Chettri (50 years old) from Upper Iche, Kalimpong, West Bengal. After qualifying for the class twelve examination, he searched for a job in the public and private sector but failed to find a job. Then, he started cultivating his ancestral land. However, he used to cultivate only 0.41 acres of area out of total available land (1.5 acres). From this area, he could produce 1.5 q maize, 3.2 q radish and 3,000 agellia with a gross income of Rs. 10,7,000 and net income of Rs.4,7,000. He was not satisfied with this limited income from farming activities and over time it was becoming difficult to run the family with this income. After getting help from the IARI under DFI, he started to grow more improved-high yielding varieties of multiple crops, like Maize, cabbage, Agellia, Orchid, Impesia and Mushrooms on 0.95 acres of area. As a result, the production of maize increased to 2 q by 2022 from 1.5 q in 2018. Similarly, the production of radish increased to 4 q (2022) from 3.2 q (2018). He also adopted new crops like red cabbage and mushroom cultivation for enhanced income. Presently, he produces 70 q red cabbage from a 0.5 acre area which is facing high market prices and generating a gross income of Rs.80,000 per year. An additional Rs.30,000 has been received from mushroom cultivation. He significantly enhanced the production capacity in floricultural activities like preparing the seedlings of agellia, orchids and impesia due to its high market demand. The annual production of seedlings of agellia, orchids and impesia has increased to 8,000 with a gross income of Rs.4,00,000 and net income of Rs.2,00,000. Thus, his gross annual income was Rs. 538000 and net income was Rs.26,100, registering a 362.86 percent increase in net income over the base year period of 2018. He took immense pride and joy that his hard work had contradicted the traditional myth that farming is a non-profitable venture, and he proved that farming can also give an equal return as business.

Table 4: Increase in production and income of beneficiary under DFI

Crop names	Benchmark (Baseline period 2018-19)				Post-intervention period (2022-23)				% increase over base year	
	Area (Acre)/ No.	Production (Q/Liter /No.)	Gross Income (Rs.)	Net Income (Rs.)	Area (Acre) / No.	Productio n	Gross Income	Net Income (Rs.)	Produ ction	Income
Maize	0.3	1.5 q	8000	3000	0.3	2 q	14000	5000	25	40
Radish	0.1	3.2 q	9000	4000	0.1	4 q	14000	7000	20	42.86
Red cabbage	-	-	-	-	0.5	70 q	80000	40000	100	100
Agellia/Or chid/ impesia	0.01	3000	90000	40000	0.03	8000	400000	200000	62.5	80
Mushroo m	-	-	-	-	0.02	6 q	30000	9000	100	100
Total	0.41	4.7/3000	107000	47000	0.95	82/8000	538000	261000	79.17	362.86


Fig. 7: Mushroom cultivation by Mr. Mahendra Chettri


Fig.8: Agellia nursery of Mr. Mahendra Chettri

Conclusion

The ICAR initiative has transformed farmers like Mira Tamang, Gyanendra Rai, Nandalal Niroula and Mahendra Chettri by providing access to improved practices, technologies, knowledge and skills. This led to enhanced farming efficiency through sustainable techniques, crop diversification, and better post-harvest management, increasing yields and reducing costs. Market linkages and financial support helped them to secure better prices, ultimately improving livelihoods, ensuring food security, and boosting incomes significantly. These successful cases proves that income can be doubled even from agricultural activities by reducing technological and knowledge gap. Therefore, the young generation should be encouraged to adopt modern farming technologies and practices for maximizing the yield and income in agricultural sector.

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ISSN : 2583-0910
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Article ID : 04/XII/19/1224

IMPORTANCE OF LAND SURFACE TEMPERATURE (LST) IN AGRICULTURAL ENGINEERING

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Abstract

Land Surface Temperature (LST) plays a crucial role in the prediction of crop yields by providing valuable insights into temperature-related stress and environmental conditions that directly affect plant growth. LST, as a measure of the surface temperature of land, offers a more accurate representation of the thermal environment that crops experience compared to air temperature alone. It influences various physiological processes in plants, including photosynthesis, transpiration, and nutrient uptake. By monitoring LST, it is possible to assess the thermal stress faced by crops, identify drought conditions, and predict the potential impacts of heatwaves on agricultural productivity. High LST values often signal the presence of heat stress, which can lead to reduced yields, water stress, and increased vulnerability to pests and diseases. Additionally, LST data, when combined with other environmental variables like soil moisture, precipitation, and crop growth models, enables more precise crop yield forecasting. This integration of LST into agricultural monitoring systems provides farmers, researchers, and policymakers with the tools necessary for effective crop management, early warning of unfavourable conditions, and improved decision-making in the face of climate variability. The importance of LST in crop yield prediction highlights its potential for enhancing food security and optimizing agricultural practices in a changing climate.

Introduction

LST is one of the key parameters in land–surface physical processes on regional and global scales and has been widely applied to hydrology, meteorology, and the surface energy balance. LST is the temperature of the Earth's surface. It reflects the amount of heat radiated from the surface of land, water bodies, and vegetation, making it a key indicator of surface thermal properties. Monitoring LST is essential for understanding local and global climate patterns, assessing the impacts of heat stress on crops, managing urban heat islands, and predicting the potential risks associated with temperature extremes. With the advent of satellite remote sensing technologies, LST can now be measured on a large scale, providing valuable data that helps in addressing environmental challenges, improving agricultural practices, and making informed decisions in the face of climate change.

Factors affecting land surface temperature

LST is influenced by a variety of factors that determine how much heat is absorbed, retained, and emitted from the Earth's surface. These factors include both natural and human-induced processes. Several factors influence LST like solar radiation, vegetation cover, soil moisture, atmospheric conditions, topography, elevation etc. LST varies more dynamically with these factors.

Measurement of land surface temperature

LST is typically measured using satellite-based thermal infrared sensors, such as those on the MODIS and Landsat satellites, which allow for monitoring over large geographic areas. The measurement of LST through satellite-based remote sensing is a multi-step process that combines radiance detection, atmospheric correction, and emissivity adjustments to provide accurate surface temperature data.

Use of land surface temperature

LST widely used in climate science, agriculture, urban planning, and environmental management to assess temperature patterns, detect heat stress in crops, understand water evaporation rates etc.

Importance of land surface temperature

The importance of LST is being increasingly acknowledged, and there is significant interest in developing methods to measure LST from space. Measurement of LST is essential for understanding and managing both natural and human-made systems. Here are several ways in which LST is important in agriculture.

1. Monitoring Heat Stress and Temperature Extremes

Crops are highly sensitive to extreme temperatures, and when temperatures exceed certain thresholds, plants may experience heat stress, which disrupts normal physiological processes such as photosynthesis, transpiration, and nutrient uptake.

2. Climate monitoring and change detection

LST is a fundamental variable for studying climate patterns and detecting trends related to global warming. By tracking changes in LST over time, one can assess warming rates and regional climate shifts, helping predict future temperature scenarios and impacts on ecosystems, agriculture, and human health.

As climate change leads to more frequent and severe temperature extremes, the impact of these changes on crop production becomes more critical. Long-term monitoring of LST provides insights into how rising temperatures and altered weather patterns are affecting crop growing seasons, yield potential, and agricultural productivity. By analyzing LST trends over time, scientists and farmers can better understand how climate change is influencing agriculture and adapt their practices accordingly. For example, the shifting of optimal growing regions due to temperature changes can lead to adjustments in crop selection and planting schedules.

3. Agricultural management, crop yield prediction and predicting productivity

LST data is crucial for monitoring crop health and predicting yields. Since plant growth is temperature-dependent, LST helps assess potential heat stress, soil moisture levels, and drought conditions, which can influence crop productivity. In areas with high LST values, farmers and agricultural planners can anticipate challenges like reduced yields and adjust water and nutrient management strategies.

Accurate crop yield forecasting is essential for planning and resource management in agriculture. LST is a valuable tool in yield prediction models because it provides a real-time measure of the thermal environment in which crops are growing. By integrating LST data with other environmental variables (e.g., precipitation, soil moisture, and solar radiation) and crop growth models, researchers can estimate the potential impacts of temperature stress on crop productivity. This combination allows for more precise yield forecasts, which are essential for farmers to anticipate potential crop losses, adjust production strategies, and ensure food security.

4. Water resource management

LST is closely linked to evapotranspiration rates, which determine how much water is lost from soil and plants into the atmosphere. By monitoring LST, water managers can estimate evaporation rates, predict drought risks, and manage irrigation needs. This is especially important in arid and semi-arid regions where water resources are limited.

5. Urban planning

By analyzing LST data, urban planners can identify hotspots within cities and develop strategies to mitigate heat stress, such as planting trees, increasing green roofs, and using reflective building materials.

6. Public health and safety

LST data can be used to assess and predict heat stress conditions, which are vital for public health. High LST values are often associated with heatwaves, which can lead to health issues like heatstroke and cardiovascular stress. Authorities use LST data to issue heat warnings, establish cooling centers, and implement policies to protect vulnerable populations during extreme heat events.

7. Ecology and habitat health

Temperature is a key determinant in the health of ecosystems and habitats. LST helps monitor habitat conditions, particularly in sensitive ecosystems like forests, wetlands, and polar regions. By tracking LST, ecologists can observe how climate change and land use alterations affect biodiversity, migration patterns, and the health of various species.

8. Assessing Drought Conditions and Water Stress

LST is closely linked to soil moisture levels and evapotranspiration, the process through which water is transferred from the soil and plants into the atmosphere. When soil moisture is low, LST tends to be higher, indicating water stress in crops. By integrating LST with soil moisture data, farmers can monitor drought conditions and determine the extent of water stress in their crops. Early identification of drought stress through LST measurements enables better water management strategies, such as optimizing irrigation or using water-saving technologies like drip irrigation to ensure crops receive adequate moisture during dry spells.

9. Crop Growth and Development

Temperature affects the rate of crop growth and the timing of key development stages, such as germination, flowering, and fruit ripening. By continuously monitoring LST throughout the growing season, farmers can assess how temperature fluctuations are impacting plant development. For instance, unusually high or low temperatures during the flowering or fruit-setting stage can lead to reduced pollination, poor fruit set, or delayed harvests, affecting overall yield. LST data helps predict these changes in growth patterns, allowing for early intervention and better management of the crop lifecycle.

10. Precision Agriculture and Decision Support Systems

In modern farming, precision agriculture relies on technology to optimize crop production and resource use. LST data collected via satellite-based remote sensing provides farmers with highly detailed and up-to-date information about the temperature variations across their fields. By analyzing spatial patterns of LST, farmers can identify areas of their fields that are experiencing different thermal conditions, such as hotspots or cooler zones, which may require targeted interventions like irrigation or fertilization. This type of data-driven, site-specific management helps improve crop yields while reducing input costs and environmental impact.

11. Integrated Pest and Disease Management

Temperature plays a significant role in the development and spread of pests and diseases that affect crops. Many pests, such as insects, and pathogens thrive in specific temperature ranges, and LST can be used as an indicator of when these threats are most likely to occur. For example, a sudden increase in LST may signal the onset of heat stress, which can weaken crops and make them more susceptible to pest infestations or fungal diseases. By using LST data, farmers can anticipate pest outbreaks and take preventive measures, such as applying pesticides or using biological controls, before pests cause significant damage.

LST data is crucial for monitoring crop health and predicting yields. Since plant growth is temperature-dependent, LST helps assess potential heat stress, soil moisture levels, and drought conditions, which can influence crop productivity. In areas with high LST values, farmers and agricultural planners can anticipate challenges like reduced yields and adjust water and nutrient management strategies.

In short, LST is a vital tool for managing environmental, agricultural, urban, and public health challenges. With advancements in satellite and remote sensing technologies, LST data continues to provide detailed insights into the Earth's thermal dynamics, supporting better decision-making and sustainable management in response to a changing climate.

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ISSN : 2583-0910
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Peer reviewed
monthly newsletter

Article ID : 04/XII/20/1224

CHALLENGES OF BREEDING MAIZE FOR SMALLER TASSELS IN A WARMING WORLD

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Abstract

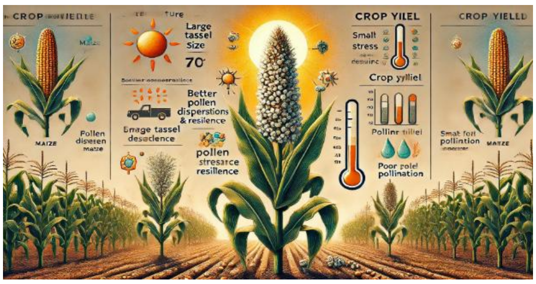
Reducing maize tassel size has been a key breeding strategy to enhance photosynthetic efficiency and increase grain yield. However, this approach may have unintended consequences under warming climates. Smaller tassels, while reducing shading of the leaves and improving light interception, are less efficient at cooling through transpiration and may compromise pollen production and dispersal under heat stress. This study examines the trade-offs between tassel size, thermal regulation, and reproductive success in maize, highlighting how climate change could challenge the benefits of current breeding practices. Results indicate that smaller tassels may exacerbate yield losses under high-temperature conditions by limiting the plant's ability to maintain pollen viability and synchrony with silking. These findings call for a revaluation of breeding strategies to balance tassel architecture with resilience to heat stress, ensuring sustainable maize productivity in a warming world.

Keyword : Tassel, Pollen, Heat stress, Climate change, Yield

Introduction

Heat waves become more serious with the warming climate, increasing the demand for developing high temperature (HT) tolerant maize germplasm. Maize (*Zea mays*) as one of the most important staple crops contributes 20-30% of human calorie requirement. With the warming climate, however, maize yield is expected to reduce dramatically (~7.4% for each 1°C increase in global average temperature), much larger than that in wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.). It is widely believed that maize tassel is more susceptible to HT stress than ear. Specifically, high temperature during flowering can advance the tasselling stage, reduce pollen shedding duration, hinder anther dehiscence, and reduce pollen viability. These high temperature induced changes independent and combined are capable of reducing seed set and even result in tassel sterility. Additionally, high temperature can slow down silk elongation and reduce silk emergence from the husk leaves, which is often neglected in studies on high temperature stress. Wang *et al.* (2021) found that the maximum temperature threshold for silk emergence ratio was ~38°C, and the ratio can be reduced by more than 20% at 40°C. Furthermore, even after silk emergence, HT can reduce silk receptivity, resulting in the failure of pollen germination or arrest of pollen tube growth. The responses of silk growth and receptivity to HT stress however remain largely unknown.

Here is an illustration visualizing the impact of maize tassel size on yield under a warming climate, highlighting differences in pollination and resilience:



1. Role of the tassel in maize pollination:
The tassel is a crucial part of maize plants because it is the male reproductive structure that produces pollen, which is essential for fertilizing the female flowers (the ears) and ultimately determining the yield. If breeders select for smaller tassels, there is a risk of reducing the plant's ability to produce sufficient pollen. This can lead to poor pollination and lower grain fill, ultimately reducing yield.

2. Warming climate and pollen dispersal:
Under warming conditions, maize is already facing challenges in terms of heat stress, particularly during the critical flowering period. High temperatures can lead to poor pollen viability, reduced pollen production, and less effective pollination. The tassel, if made smaller, may be less effective at dispersing pollen under these conditions, compounding the problem of heat stress.

3. Breeding for smaller tassels:
The rationale behind breeding for smaller tassels may stem from various factors, such as reduced risk of disease or a desire to direct more energy toward kernel production rather than vegetative growth. However, if not carefully balanced, reducing the size of the tassel can inadvertently undermine the plant's ability to produce pollen, thus decreasing overall reproductive success.

4. Potential trade-offs:
When breeding for traits like smaller tassels, breeders need to consider the balance between vegetative growth and reproductive success. While reducing tassel size could improve other aspects of maize growth, such as stress tolerance or resource allocation, it could come at the cost of reduced pollination efficiency especially in the face of hotter and more variable climates.

5. Climate adaptation strategies:
To address these challenges, breeding programs might need to focus on climate-resilient traits, such as:

- **Heat tolerance**: Maize varieties with better heat tolerance during flowering can better withstand high temperatures and ensure optimal pollen production.
- **Drought tolerance**: Since water stress can also affect pollination, breeding for drought-resistant maize could complement efforts to mitigate the negative impacts of warming.
- **Improved tassel architecture**: Instead of simply making the tassel smaller, breeders could focus on optimizing tassel structure to ensure adequate pollen production and dispersal while still improving other aspects of the plant's performance.

6. Agroecological considerations:
In addition to breeding, integrated approaches to climate adaptation should also consider changes in agronomic practices. For example, adjusting planting dates, optimizing irrigation, and using cover crops could help maize plants cope with warming climates and maintain high yields.

In summary, while breeding maize for smaller tassels might have some theoretical benefits, it poses risks to yield under warming climates by reducing the plant's pollen production and effectiveness in pollination. This challenge highlights the need for breeding strategies that prioritize both heat tolerance and effective reproduction, ensuring that maize can thrive in increasingly variable environmental conditions.

Conclusion

While breeding maize for smaller tassels has improved photosynthetic efficiency and yield under optimal conditions, this strategy poses significant risks in the context of a warming climate. Smaller tassels are less effective at dissipating heat and maintaining pollen viability under high temperatures, potentially leading to poor pollination and reduced grain yield. As global temperatures rise, the trade-offs between tassel size and thermal regulation become more pronounced, underscoring the need to prioritize climate resilience in maize breeding programs. Future breeding strategies should integrate genetic diversity and innovations that balance tassel architecture with enhanced tolerance to heat stress, ensuring food security in the face of climate change.

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ISSN : 2583-0910
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Peer reviewed
monthly newsletter

Article ID : 04/XII/21/1224

MANGO FRUIT BLACKENING CAUSED BY SOOTY BLOTCH WITH ARKA MANGO WASH TECHNOLOGY TO BOOST MANGO MARKETABILITY

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Mangoes, often called as the "king of fruits," occupy a cherished place in Indian culture, cuisine, and agricultural history. Known for their succulent sweetness and rich, tropical flavor, mangoes have become an essential part of culinary traditions and everyday meals throughout country. India, the world's largest producer of mangoes, contributes a staggering 50% to global mango production. India's favorable climate and diverse soil types make it an ideal region for mango cultivation. With over 1,000 varieties cultivated across the country, Indian mangoes are prized for both their table and processing uses. In the year 2023, India produced approximately 21 million metric tons of mangoes, grown over an estimated 2.3 million hectares of land. Furthermore, India stands out as a key exporter of fresh mangoes, having shipped 32,104.09 metric tons valued at Rs. 495.46 crores (USD 60.14 million) during the year 2023-24 (Ref). As the world's leading producer of mangoes, India's mango industry not only caters to the vast domestic market but also plays a significant role in global fruit trade. Major export destinations include the United Arab Emirates, the United Kingdom, the United States, Kuwait, and Qatar (ref). This robust production and export framework underscore the vital role mangoes play in India's agricultural economy and its global market presence.

Among the leading mango-producing states of India, Karnataka shines brightly with its rich mango-growing heritage. Karnataka's mango cultivation is distinguished by the production of several premium varieties, including Alphonso, Totapuri, Banganapalli, Neelam and Mulgoa. Regions within Karnataka such as Bagalkot, Bijapur, Tumkur, and Chikballapur are particularly noted for their thriving mango orchards.

The mango marketing challenge: impact of blackening

Despite the inherent profitability and high demand for mangoes, farmers often encounter significant challenges in marketing their produce. One of the most critical issues is the blackening of mangoes, which can drastically affect visual appeal and marketability of fruits. Mangoes that exhibit visible blackening or blemishes are frequently rejected by buyers, even though the internal quality of the fruit remains unaffected.

This issue of mango blackening poses a serious problem for farmers, who may face substantial financial losses due to the reduced market value of their produce. The inability to sell blemished mangoes at competitive prices not only affects the farmers' income but also adds a layer of uncertainty in marketing.

Among the various factors contributing to mango blackening, sooty blotch is a is of major concern which is caused by a complex of fungi that colonize the waxy layer of mangoes. The fungi create dark, irregular blotches on the fruit's surface, which significantly diminish its visual appeal.

These fungal colonies can spread from the fruit's shoulder area and eventually cover the entire surface, leading to extensive blackening.

The presence of black patches makes the fruit less attractive to buyers, leading to lower prices and decreased sales opportunities. For farmers, this translates into potential financial losses.

Mangoes infected with sooty blotch. Mild (left) Moderate (mid) severe (right) incidence

Arka mango wash: a game-changer in mango care

In response to the challenge of sooty blotch, the ICAR-Indian Institute of Horticultural Research has developed the Arka Mango Wash technology. This innovative post-harvest treatment is designed to address the problem of blackening and restore the fruit's appearance, thus enhancing its marketability.

Arka Mango Wash is a simple yet effective technology that involves dipping mangoes affected by sooty blotch in a specially formulated solution. The treatment is aimed at removing the blemishes caused by fungal colonies and improving the overall visual appeal of the mangoes.

Detailed Process:

1. Preparation of the Wash Solution:
   * **Ingredients:**
     - Solution A: 250 ml (4% concentration)
     - Solution B: 9 ml (85% concentration)
   * **Mixing:**
     - Combine Solution A and Solution B in 10 liters of potable water to create a 1000 ppm mango wash solution.
     - Use a pH meter or pH paper to adjust the pH of the solution to 6.5.

2. Application Process:
   * **Dipping**:
     - Submerge the sooty blotch-infected mangoes in the prepared solution for 10-15 minutes to remove the fungal blemishes present on waxy layer.
   * **Post-Treatment**:
     - After removing the mangoes from the solution and rinse them twice with normal water. This step ensures the removal of residues if any., on fruit surface. .

- Allow the treated mangoes to shade dry before proceeding to the ripening process. Proper drying is essential for maintaining fruit quality and preparing the mangoes for market.

Sooty blotch infected untreated mangoes

Mangoes treated with Arka mango wash technology

Benefits of arka mango wash:

- Effective Removal of Blackening: The treatment is capable of removing around 99% of the blackening caused by sooty blotch. This significant improvement in appearance can make a substantial difference in market acceptance.
- Cost-Effective Solution: At a cost of approximately ₹1 per kilogram of mango, Arka Mango Wash offers an affordable option for farmers. This low-cost treatment helps reduce financial strain and improves the overall profitability of mango farming.
- Enhanced Market Value: By restoring the fruit's visual appeal, Arka Mango Wash helps farmers achieve better prices for their produce. This enhanced market value can lead to increased income and financial stability for growers.

Embracing innovation for a brighter future

The introduction of Arka Mango Wash technology marks a significant advancement in post-harvest mango care by effectively addressing the blackening caused of sooty blotch fungal complex. This technology enhances the appearance of mangoes, enabling farmers to secure better market prices and reduce financial losses.

The success of Arka Mango Wash technology highlights the critical role of innovation in agriculture. It exemplifies how a simple, cost-effective approach can revolutionize mango farming. As farmers navigate various challenges in crop management and marketing, the development and adoption of practical, affordable solutions like this can transform the industry. By embracing such technologies, the farming sector can thrive, ensuring that India's commodities continue to be a valued for its potential driving agricultural and economic prosperity.

Please take a note!

Arka mango wash works exclusively on blackening caused by sooty blotch fungal complex grown on waxy layer of mango fruits. Sooty mould and other mango skin abnormalities occurring on the fruit skin depicted in this page either due to shoulder browning, anthracnose, bacterial canker, scab, thrips damage or bigger lenticels cannot be removed by Arka mango wash technology. For more details, please write to Director, ICAR-IIHR, Bengaluru-560089.

ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/22/1224

ROLE OF MARKET INTELLIGENCE FOR DOUBLING FARM INCOME: A CASE OF TIMBER CROPS

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Introduction

Forests are invaluable resources that provide a wide array of products essential for human well-being and economic development. From timber and paper to medicinal herbs and resins, forest products play a vital role in various industries and livelihoods worldwide. However, the sustainable management and utilization of forest resources require comprehensive understanding and analysis of market dynamics, consumer preferences, and industry trends. Timber crops constitute a significant segment of the forest products industry, playing a crucial role in various sectors such as construction, furniture manufacturing, and paper production. As the demand for timber continues to rise globally, driven by urbanization, infrastructure development, and population growth, there is a growing need for comprehensive market intelligence to guide sustainable management practices and strategic decision-making.

Market Intelligence refers to systematic collection and analysis of data or information from the relevant sources to ascertain the changing trends in the timber species marketing environment. In other words, the farmer/ agripreneur or trader collects the necessary data from all the available sources and analyse the data into meaningful conclusion that can be used in critical decision making. Further, the analyzed data can be sent to the end users like farmer/ producer/ trader through various channels like newspapers, magazines, books, trade publications, SMS and social media.

Need for market intelligence for timer crops:

There are excess market intermediaries in the marketing channel, which makes the supply chain lengthier than the normal/ optimal. This makes the market as inefficient which reduces the producer's share in consumer rupee. To overcome this situation, farmers need accurate market information on arrivals and prices at different markets. The Market Intelligence serves as a specialized unit focused on gathering, analyzing, and disseminating critical market insights related to timber species, including market trends, supply chains, pricing dynamics, and regulatory frameworks. By harnessing the power of data-driven analysis, the market intelligence empowers stakeholders to navigate complex market landscapes, mitigate risks, and capitalize on emerging opportunities in the timber sector.

Through a combination of market analysis, technological integration, stakeholder engagement, and capacity building initiatives, the market intelligence aims to address the following key objectives:

Market insight: Provide timely and accurate information on market trends, demand-supply dynamics, pricing structures, and competitive landscapes for various forest products.

Strategic planning: Assist policymakers, forest managers, and industry stakeholders in formulating strategic plans, investment decisions, and resource allocation strategies based on market intelligence insights.

Risk mitigation: Identify potential risks and vulnerabilities associated with market fluctuations, regulatory changes, and environmental factors, and develop proactive measures to mitigate these risks.

Value addition: Identify value-added opportunities, niche markets, and emerging trends to enhance the value proposition of forest products and promote innovation in product development and marketing strategies.

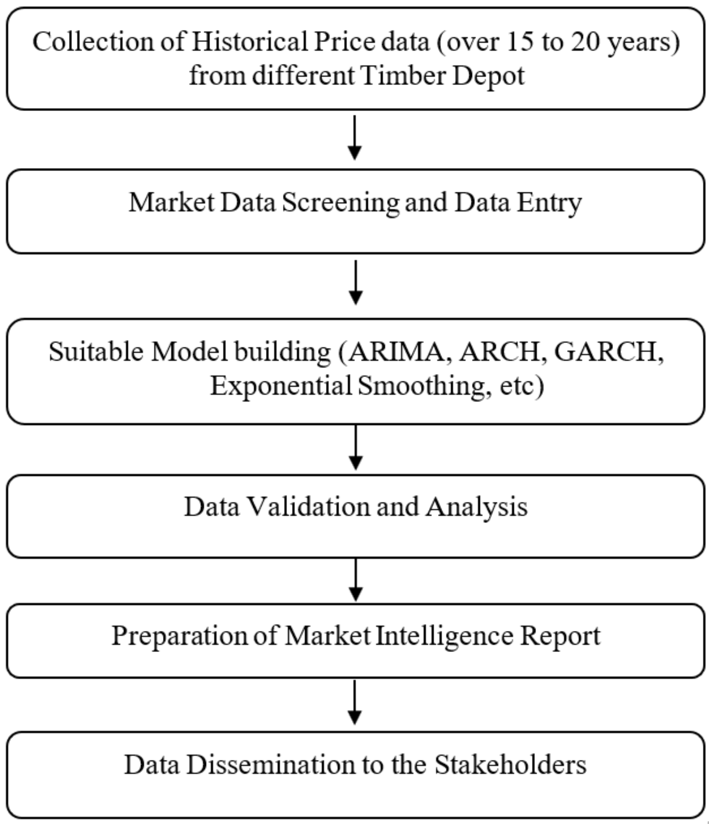
Sustainability: Promote sustainable forest management practices by analyzing market demand for sustainably sourced products, tracking certification standards, and facilitating market access for eco-friendly products.

Capacity building: Build the capacity of forest industry professionals, market researchers, and policymakers through training programs, workshops, and knowledge-sharing initiatives on market intelligence methodologies and best practices.

Stakeholder collaboration: Foster collaboration and information exchange among forest departments, industry associations, research institutions, NGOs, and local communities to leverage collective expertise and resources for market development and conservation efforts.

By establishing a dedicated Market Intelligence Cell / Wing for forest products, stakeholders can harness the power of data-driven decision-making to unlock the full economic potential of forest resources while safeguarding environmental integrity and promoting social equity. This market intelligence outlines the framework and strategies for realizing the vision and underscores the importance of proactive market intelligence in shaping the future of the forest products industry.

Methodology involved in market intelligence:



Various time forecasting models would be used to forecast the prices for timber crops and are listed below:

a) Exponential Smoothing
b) ARIMA Models (Autoregressive Integrated Moving Average)
c) Seasonality
d) ARCH (Autoregressive conditional Heteroscedasticity)
e) GARCH (Generalized Autoregressive conditional Heteroscedasticity)

Advantages of market intelligence:

Agricultural marketing intelligence helps farmers in knowing the answers of various questions such as when to sell? Where to sell? Whether to sell now or later? Marketing Intelligence also help farmers in choosing cropping patterns for higher value crop produce Agricultural marketing intelligence helps farmers in knowing the answers of various questions such as when to sell? Where to sell? Whether to sell now or later? Marketing Intelligence also help farmers in choosing cropping patterns for higher value crop produce agricultural marketing intelligence helps farmers in knowing the answers of various questions such as when to sell? Where to sell? Whether to sell now or later? Marketing Intelligence also help farmers in choosing cropping patterns for higher value crop produce.

- It helps authorities to monitor market price of different agricultural marketing intelligence helps farmers in knowing the answers of various questions such as when to sell? Where to sell? Whether to sell now or later? Marketing Intelligence also help farmers in choosing cropping patterns for higher value crop produce.
- It helps authorities to monitor market price of different agricultural
  - ✓ Market Intelligence provides insights into the market dynamics of arrivals, demand and price trends of timber crops at a specific point of time.
  - ✓ It helps the farmers to take decisions on when to sell and where to sell the timer crops to realize higher producer's share in consumer rupee.
  - ✓ It helps market intermediaries to identify markets having high demand for a specific timer wood.
  - ✓ It also helps the farmers to minimize the transportation cost by selecting shorter and efficient marketing channel.

Conclusion

The market intelligence will act as an important input for improved strategic decision making of famers by providing timely and relevant insights into market price dynamics and consumer demand. Further, the market intelligence analysis will be useful for identification of market opportunities for timber products and helps to increase revenue and profitability of the farmers.

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Article ID : 04/XII/23/1224

MITIGATING POST HARVEST LOSS OF CASSAVA TUBERS THROUGH VALUE ADDITION

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Summary

A major practice to mitigate Postharvest loss and wastage is value addition, either by processing or packaging, or both. This review summarizes various environmentally friendly methods of value addition to cassava. Adding value to cassava roots involves a combination of different factors like; processing, innovation, and market analysis. The diversification of cassava products will contribute to efforts already made in food security and create opportunities for economic growth and sustainability.

Introduction

Addressing food security challenges is vital to the future of Africans and Nigerians (Okolo, 2004). Despite the economic importance of cassava to the teaming populace in Nigeria, it is not devoid of post-harvest losses. Cassava (*Manihot esculenta*) can be considered one of the major staple foods around the globe (Tadele and Assefa, 2012; Fakayode *et al.*, 2008). The Food and Agriculture Organization (FAO, 2011) states that *Manihot esculenta* holds the fourth rank as a main staple crop in developing countries, right after wheat, rice, and maize. Cassava is progressing into a major commercial and industrial trend around the globe, mostly because it can easily be adapted to flourish in varied soil conditions and climates (Mtunguja *et al.,* 2019).

Cassava is the most important root crop in Nigeria. Currently, the country produces about 40,000,000 tons of the cassava tubers annually (Olayemi *et al.,* 2011). Apart from being a staple crop in both rural and urban households, cassava is a major source of income to cassava farmers and processors in the rural areas (Danilola *et al*., 2019).

Cassava alone contributes about 45% of agricultural GDP in Nigeria for food or domestic purposes but its industrial processing and utilization has been very limited (Oluwatusin, 2017). Value addition of cassava is therefore necessitated by the rapid post-harvest spoilage and, deterioration as well as the need to diversify taste and ensure consumer acceptability.

Value addition of Cassava

Value addition involves the conversion of edible food into another form more stable, acceptable or more convenient to the consumer (Abubakar, 2003). Alternative uses of cassava through value addition have resulted in emergence of wide food recipes from cassava through processing. Some value added products from cassava include Cassava flour, Cassava starch, Cassava bread, Cassava chin-chin, Cassava chips, Cassava flakes, Cassava odourless fufu, Cassava doughnut, Cassava cake, Cassava biscuit and Cassava salad cream. The value addition technology in cassava possesses enormous potentiality for increasing cassava consumption, diversifying its uses as well as using same to enhance livelihoods of farm families through providing opportunities for employment

(Achinewhu and Onwuama, 2000). Some of the ways to add value to cassava are examined in this article.

Odourless fufu flour

fufu is a fermented wet-paste made from cassava and prepared by cooking into a thick gelatin; usually consume with sauces or stew of meat, fish or vegetables. Fufu is very rich in carbohydrate and has smooth texture. It is ranked next to garri as an indigenous food of most Nigerians in the south (Foraminifera, 2021). Traditionally, it is produced in the wet form with moisture content of 40-50 per cent with an offensive characteristic odour. This makes the product highly perishable with a short shelf life compared with garri and lafun (another form of cassava food also consumed with sauces) which are in granular form with moisture content below 10 percent (Foraminifera, 2021).

In order to increase the shelf life, improved fufu production process has been developed (Achi and Akomas, 2006). The improved method of processing which is different from the traditional production process starts by peeling of tubers, washing, cutting into pieces and steeping in water to ferment for 3–4 days with daily water change. The fermented mash is pounded or simply washed over a fine sieve to remove fibre and the water expelled from the starch extract by pressing through muslin cloth, dried, milled and sieved to produce odourless fufu flour.

High quality cassava flour (HQCF)

Cassava roots can be processed into high quality cassava flour and used in various culinary applications. HQCF is simply unfermented cassava flour, usually whitish or creamy in colour, odourless, bland or sweet in taste and free from adulterants, insect infestation, sand, peel fragments, dust, and any other impurities (Nanam TayDziedzoave *et al*., 2017). The HQCF can be used in baking to make products such as bread. Cassava flour is gluten-free and can be used as a substitute for wheat flour in baking.

Production starch

Extraction of cassava starch can be a profitable venture. Starch has numerous industrial applications, including the food industry, papermaking, and textile manufacture.

Cassava chips

Cassava chips are unfermented white dried products of cassava with an average diameter of 3mm – 5mm often used as a carbohydrate base in the animal feed industry particularly in Europe. It can be milled into flour for other uses such as production of ethanol, cakes, doughnut and biscuits. Cassava chips is made by slicing cassava tubers into thin chips and dried. These cassava chips can also be used as a snack or an ingredient in various dishes. Proper drying methods are crucial to ensuring quality.

Cassava-based snacks

A variety of snacks, such as cassava crisps, cassava fries, or cassava-based chips are made from fresh sweet cassava tubers either by roasting or dried. These products can be seasoned and packaged for retail and can be consumed directly as other snacks. (Fernanda *et al.,* 2015).

Cassava-based beverages

Beverages such as cassava juice, energy drinks, and cassava-based alcoholic drinks have been developed from cassava with proper processing and flavouring. Cassava Chicha, a beverage known as indigenous beer, or Masato is consumed daily by populations located in the jungle and around the Amazon River (Caicedo and Espinel, 2018; Grijalva-Vallejos *et al.,* 2020; Hirsch, 2017). Its preparation is a task carried out by women and consists of peeling, washing and boiling the cassava roots of sweet or bitter varieties, indistinctly until softened, the water is drained and the cassava is crushed in flat round wooden trays, the remains of cassava pieces are chewed and periodically spit into the tray (Colehour *et al.,* 2014; Freire *et al.,* 2016; Vallejo *et al.,* 2013).

Biofuel production

Cassava roots have been used in the production of biofuels, such as ethanol (Ogundari *et al.,* 2012). This can be an environmentally friendly way to utilize cassava and contribute to renewable energy sources. When ethanol yields per unit area of cultivations are compared, cassava is the highest potential crop to gain the highest yield (Krajang *et al.,* 2021).

Animal feed

Cassava peels and by-products can be processed into nutritious animal feed. This adds value to cassava waste and provides a supplementary income stream.

Cassava-based skincare products

Useful compounds from cassava have found usage in skincare products (Tanya, 2024). Cassava has potential benefits for the skin, and incorporating it into cosmetic products may appeal to a niche market. Vitamin C in cassava helps boost collagen synthesis in the body, thus helping improve the skin's elasticity and texture (Pullar *et al.,* 2017). Besides, the peel of cassava fruit acts as a natural skin exfoliator and may help remove a layer of dead skin cells. The tuberous vegetable is also said to lighten dark spots and hydrate the skin.

Conclusion

Cassava processing is profitable agricultural activity. Value addition to cassava tubers will not only mitigate against post harvest loss but will greatly contribute to the economy, improve the livelihood of famers and processors as well as providing employment along the value chain.

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ISSN : 2583-0910
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Article ID : 04/XII/24/1224

CLIMATE CHANGE IN FARMING: SUCCESSFUL SOLUTIONS

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Introduction

Climate change is a major issue impacting every aspect of our lives, particularly agriculture, a vital sector for our sustenance. The increasing variability in weather patterns, such as unpredictable rainfall and extreme events like floods, droughts, and cyclones, poses serious challenges to global agriculture. These changes directly affect crop yields, livestock health, and farmers' livelihoods. To combat this, the agricultural sector must adapt to shifting weather patterns, increased extreme events, and the changing prevalence of pests and diseases. In response, the Government of India, along with farmers worldwide, has implemented a variety of projects focused on mitigating and adapting to climate change. These initiatives not only promote sustainable agricultural practices but also contribute to broader environmental goals, such as reducing greenhouse gas emissions and enhancing biodiversity. Farmers are embracing sustainable practices that improve soil health, conserve water and cut emissions, while using technology like precision agriculture and weather forecasting to make informed decisions. By cultivating resilience through planting drought-resistant crops and diversifying operations, farmers are leading a growing movement that demonstrates how food production and environmental responsibility can coexist. By learning from their successes, we can inspire all farmers to become stewards of a more sustainable future.

Climate change is defined as a shift in the Earth's climate caused by human activities, either directly or indirectly. These activities alter the composition of the global atmosphere, leading to changes that surpass natural variability over time (UNFCCC, 1992). Among the 17 Sustainable Development Goals (SDGs) set by the United Nations, Goal 13 focuses on climate action, aiming to take urgent steps to combat climate change by strengthening resilience and raising awareness. India faces increasing climate change challenges, including more frequent and intense extreme weather events. Without adaptation, millions will be affected by river floods, sea-level rise, and heat waves, with potential job losses due to heat-induced productivity declines. By the end of the century, temperatures could rise by 1.1-4.1°C, impacting economic growth, natural resources, and vulnerable populations, particularly poor farmers, coastal and forest communities, and women. States like Jharkhand, Mizoram, Odisha, and Chhattisgarh are among the most vulnerable, while regions like Bihar, Uttar Pradesh, and Assam are at high risk of infrastructure damage by 2050 according to national assessments.

Causes of climate change

Climate change is driven by a complex interplay of natural and human factors. Understanding these causes is crucial for addressing the impacts and developing mitigation strategies.

Natural factors

- **Solar radiation variations**: The amount of solar energy reaching the Earth varies due to changes in the Sun's output and the Earth's orbit and tilt. These variations can cause significant climate changes over geological time scales, such as the ice ages.

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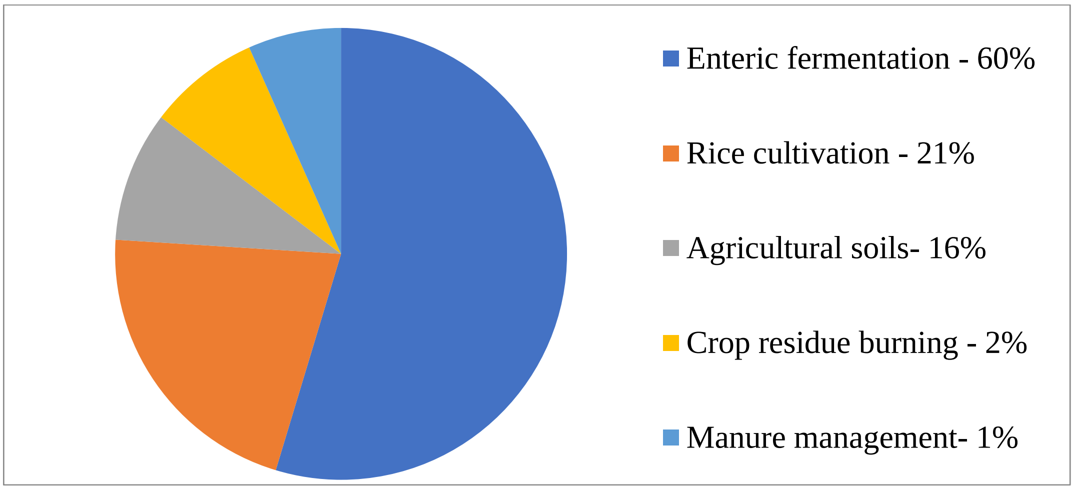
- **Volcanic activity**: Volcanic eruptions release large quantities of sulfur dioxide (SO2) and ash into the atmosphere. These particles can reflect sunlight and cool the Earth's surface temporarily. However, volcanic CO2 emissions also contribute to the greenhouse effect over longer periods.
- **Ocean currents:** Oceans play a crucial role in climate regulation by redistributing heat around the planet. Changes in ocean currents, like El Niño and La Niña events, can lead to significant short-term climate variations.
- **Natural greenhouse gas emissions:** Natural sources of greenhouse gases, such as wetlands emitting methane (CH4) and natural processes that release carbon dioxide (CO2), contribute to the atmospheric greenhouse gas concentrations.

Human factors

- **Burning of fossil fuels:** The combustion of coal, oil, and natural gas for energy and transportation releases large amounts of CO2 and other greenhouse gases into the atmosphere. This is the primary driver of recent climate change.
- **Deforestation:** Clearing forests for agriculture, logging, and development reduces the number of trees that can absorb CO2 from the atmosphere. This not only increases CO2 levels but also disrupts local and global carbon cycles.
- **Industrial processes:** Industries release various greenhouse gases, including CO2, methane (CH4), and nitrous oxide (N2O), as well as synthetic gases like chlorofluorocarbons (CFCs) and hydro fluorocarbons (HFCs), which have a much higher global warming potential than CO2.
- **Agriculture:** Agricultural practices, including livestock farming, produce significant methane emissions. Rice paddies and the use of nitrogen-based fertilizers also contribute to methane and nitrous oxide emissions, respectively.
- **Urbanization:** The expansion of cities leads to increased energy consumption and changes in land use, which can alter local climates and contribute to higher greenhouse gas emissions.
- **Waste management**: Landfills produce methane as organic waste decomposes anaerobically. Inadequate waste management practices can increase the release of this potent greenhouse gas.

Contribution of agriculture to GHG emission in India

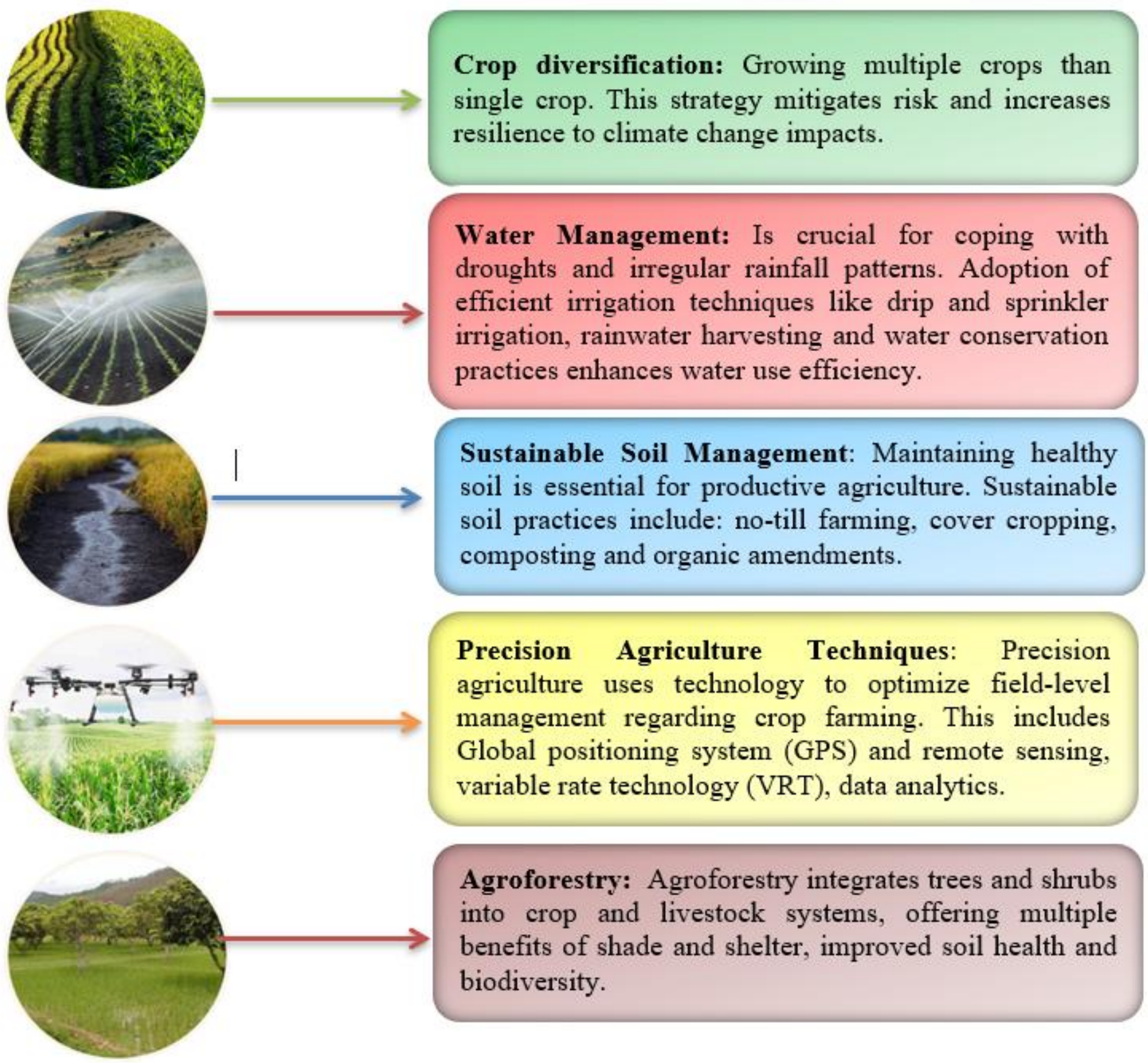


Climate change risks in agriculture

Climate change poses significant risks to agriculture, impacting both crop and livestock production. Extreme heat, drought, flooding, and severe weather events can damage crops, reduce yields, and lower crop quality. Additionally, warmer temperatures and changing weather patterns increase the prevalence of pests and diseases. Livestock face similar challenges, such as heat stress, water shortages, and increased diseases and parasites, which affect their health, growth, and productivity.

These climate-related challenges also lead to soil erosion and degradation, further reducing agricultural productivity. The economic impact includes financial losses for farmers, higher food prices, and increased food insecurity. To adapt, farmers can diversify crops, improve water management, protect soil health, and use climate-resilient crop varieties and livestock breeds. Implementing these strategies can help mitigate the risks and ensure sustainable agricultural practices in the face of climate change.

Strategies to mitigate risks of climate change in agriculture



Successful projects for climate change management

1) National Innovations in Climate Resilient Agriculture (NICRA)

2) Enhancing Climate Resilience of India's Coastal Communities (ECRICC)
3) National Mission on Sustainable Agriculture (NMSA)
4) National Cyclone Risk Mitigation Project (NCRMP)
5) National Mission for Green India (GIM)
6) AICRP on Agrometeorology
7) Navakiranam Project
8) Climate Change Knowledge Network in Indian Agriculture (CCKN-IA)

1) National Innovations in Climate Resilient Agriculture (NICRA)

The National Innovations in Climate Resilient Agriculture (NICRA) Project, initiated by ICAR in 2011, aims to enhance the resilience of Indian agriculture to climate variability and change. On-farm participatory demonstrations for climate resilience are being implemented in village clusters through KVKs in 121 climatically vulnerable districts across the country and by 7 core research institutes of ICAR.

Key interventions under the NICRA project (ATARI Zone-XI) include:

- **Natural Resource Management:** Improved drainage, water harvesting structures, and moisture conservation, covering 648.6 hectares and benefiting 1,276 farmers.
- **Crop Production:** Introduction of drought-tolerant crops, crop diversification, and water-saving techniques, covering 411.75 hectares and benefiting 2,272 farmers.
- **Livestock and Fisheries:** Fodder production, improved shelters for livestock, and fish pond management, benefiting 1,991 livestock owners.
- **Institutional Interventions:** Establishment of seed and fodder banks, custom hiring centres, and village-level weather stations benefiting 2,997 farmers.

2) Enhancing climate resilience of india's coastal communities (ECRICC)

ECRICC (2019-2025) is a six-year project aimed at building the climate resilience of vulnerable populations, especially women, in coastal areas of India. It is executed by the Ministry of Environment, Forest and Climate Change (MoEFCC) in collaboration with state departments in Andhra Pradesh, Maharashtra and Odisha, with funding from the Green Climate Fund (GCF) and support from UNDP.

Key interventions of the project include:

- **Enhanced resilience of coastal and marine ecosystems:** ECRICC works on restoring degraded ecosystems like mangroves, sea grass meadows, and salt marshes, as well as conserving endangered species such as sea turtles.
- **Climate-adaptive livelihoods for coastal communities:** The project focuses on skill development in areas like sustainable aquaculture, eco-tourism, and climate-smart agriculture, along with supporting value chain improvements and climate-proofing existing livelihoods.
- **Strengthened governance and institutional frameworks:** ECRICC supports policy development, capacity building, and collaboration among stakeholders to ensure effective coastal management and adaptation to climate change.

3) National Mission on Sustainable Agriculture (NMSA)

The National Mission on Sustainable Agriculture (NMSA), launched in 2014-15 under the National Action Plan on Climate Change (NAPCC), aims to make Indian agriculture more productive, sustainable, and climate-resilient.

Key interventions:

- **Rainfed Area Development (RAD)**: Promotes integrated farming systems by combining crops, livestock, fisheries, and agro-based activities in rainfed regions, emphasizing resource conservation and nutrient management.
- **Sub-Mission on Agroforestry (SMAF)**: Encourages the planting of trees on farmlands to improve soil health, increase forest cover, and enhance crop productivity while promoting sustainable agroforestry practices.
- **Soil Health Management (SHM)**: Implements sustainable soil management practices through soil fertility mapping, nutrient management, and reclamation of problematic soils to enhance soil quality and crop yields.
- **Climate Change and Sustainable Agriculture (CCSAMMN)**: Develops and spreads climate-smart farming techniques and integrates rainfed technologies with flagship agricultural programs to ensure climate resilience.

4) National Cyclone Risk Mitigation Project (NCRMP)

The National Cyclone Risk Mitigation Project (NCRMP), coordinated by the National Disaster Management Authority (NDMA) under the Ministry of Home Affairs, aims to reduce vulnerability in cyclone-prone states and Union Territories of India.

Key Interventions of the NCRMP Project:

- **Early Warning Dissemination Systems:** Installation of systems to provide timely cyclone warnings across coastal districts, improving preparedness and response times.
- **Cyclone Shelters:** Construction of multi-purpose cyclone shelters to provide safe refuge for vulnerable populations during cyclones.
- **Infrastructure Development:** Building and upgrading critical infrastructure, including connecting roads, bridges, saline embankments, and underground electrical cabling, to ensure accessibility and resilience.

5) National Mission for Green India (GIM)

The National Mission for Green India (GIM) is one of the eight Missions outlined under the National Action Plan on Climate Change (NAPCC).

Key interventions:

- **Enhancing Forest and Ecosystem Quality (SM-1)**: Improving the quality of existing forests and enhancing ecosystem services such as carbon sequestration, hydrological functions, and biodiversity.
- **Ecosystem Restoration and Forest Cover Increase (SM-2)**: Restoring degraded ecosystems and increasing forest cover across India, aiming for an additional 5 million hectares of forest area.
- **Urban and Peri-Urban Tree Cover (SM-3)**: Promoting tree planting in urban and peri-urban areas, including institutional lands, to increase green cover and improve air quality.
- **Agro-Forestry and Social Forestry (SM-4)**: Expanding tree plantations in agricultural and community lands to increase biomass and create carbon sinks.
- **Wetland Restoration (SM-5)**: Rehabilitating and protecting wetlands, enhancing their role in supporting biodiversity and providing ecosystem services.

6) AICRP on Agrometeorology

The All India Coordinated Research Project on Agrometeorology (AICRPAM) was started during May 1983 with its Coordinating Unit at the Central Research Institute for Dryland Agriculture, Hyderabad and ten Cooperating Centres at Anantapur, Anand, Bangalore, Hisar, Jabalpur, Ludhiana, Mohanpur, Ranchi, Solapur and Varanasi. The programme was further strengthened and now its covering 25 SAUs in the country.

Key Interventions

- **Agro-climatic Zoning**: Development of agro-climatic zones to tailor agricultural practices to local weather patterns.
- **Crop Weather Models**: Development and refinement of crop-weather models to predict crop yields and manage climate risks.
- **Agromet Advisory Services (AAS)**: Providing weather-based agro-advisories to farmers for decision-making in farming activities.
- **Technology Transfer**: Establishment of agromet field units for the dissemination of technology and weather-based advisories.
- **Data Collection and Analysis**: Creation of a vast network for collecting weather and crop data, enhancing the capacity for research on climate impacts

7) Navakiranam Project

The Kerala Govt-introduced a novel scheme under its Rebuild Kerala Initiative to support voluntary relocation for settlements marooned within forest enclosures and forest fringes. Total amount released for the project is 73.125 cr.

Key Interventions

- **Voluntary Relocation**: Providing financial support and incentives to families residing in forest enclosures and fringes to relocate voluntarily to safer and more accessible areas.
- **Rehabilitation Assistance**: Ensuring that relocated families receive housing, access to quality education, healthcare, and basic amenities in their new settlements.
- **Conflict Resolution**: Addressing the long-standing conflict between forest management and the developmental needs of people by relocating settlements away from environmentally sensitive forest areas.
- **Conservation and Livelihood Integration**: Balancing the need for protecting natural ecosystems with the need to provide sustainable livelihoods for people previously living in forest enclosures.

8) Climate Change Knowledge Network in Indian Agriculture (CCKN-IA)

This project is developed by MANAGE, MoAFW, Govt. of India started in the year 2015 in 3 states (Maharashtra, Jharkhand and Odisha).

Key interventions:

- **ICT-Based Knowledge Platform**: Development of an innovative platform to process and disseminate real-time information on agricultural production, markets, climate, and weather events, enhancing farmers' access to critical knowledge.
- **NICE Tablet Applications**: Use of tablet-based applications to facilitate the exchange of advisories and climate-smart agricultural practices, improving decision-making for farmers.
- **Baseline Studies**: Conducted in 270 villages across Maharashtra, Jharkhand, and Odisha to understand local climate challenges and agricultural needs.
- **WhatsApp-Based Advisory Networks**: Creation of 1,000 WhatsApp groups in 12 pilot blocks to share climate and agricultural advisories directly with farmers, fostering real-time communication and support.

Conclusion

Climate change presents significant challenges for farmers, including unpredictable weather patterns, water scarcity, soil degradation, and increased prevalence of pests and diseases. To address these issues, governments have implemented various projects and initiatives aimed at mitigating the impacts of climate change on agriculture. These measures include providing financial assistance, promoting sustainable farming practices, and developing climate-resilient crop varieties. Despite these efforts, farmers continue to face substantial difficulties due to the rapidly changing climate. Therefore, it is crucial for governments to expand their initiatives, focusing on comprehensive training and awareness programs that equip farmers with the knowledge and skills necessary to adapt to these changes effectively. By enhancing support systems and fostering resilience among farming communities, we can ensure a more sustainable and secure agricultural future in the face of ongoing climate challenges.

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Article ID : 04/XII/25/1224

ADVANCED PCR TECHNIQUES IN GENE CLONING AND GENETIC ENGINEERING

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Abstract
Essentially every area of molecular biology now utilizes the polymerase chain reaction (PCR), which has become a widely adopted technique. Cloning DNA fragments amplified by PCR has been facilitated by the development of innovative ligation-independent techniques. Cloning genes and recombinant PCR are efficiently achieved with uracil DNA glycosylase (UDG) cloning, a ligation-independent method. This approach is now employed to create nested deletions, build new gene constructs and perform site-directed mutagenesis. PCR amplification, along with the methodology's ease of use and versatility, streamline gene cloning and engineering procedures.

Key words : Gene cloning, Independent cloning, UDC cloning, Novel genes, CNTF

Introduction

Nowadays, the polymerase chain reaction (PCR) is one of the most potent tools in molecular biology, with widespread applications (Erlich *et al.,* 1991). Amplifying DNA sequences prior to cloning is a standard procedure, and numerous variations of the original PCR technique have been developed. The ability to clone and build new genes has been greatly enhanced by the use of PCR for nucleic acid amplification. For the purpose of creating recombinant genes, PCR amplification has emerged as a useful adjunct to traditional recombinant DNA techniques. Without the need for complex DNA engineering, it is now possible to ligate different DNA segments thanks to a technique known as "recombinant PCR."

When a researcher has access to PCR equipment, they can quickly obtain huge quantities of any DNA fragment whose nucleotide sequence is known. Theoretically, any gene with a published nucleotide sequence can be cloned due to the ease of access to highly concentrated DNA segments from genomic DNA. Additionally, PCR makes it possible to create new DNA fragments, or synthetic genes, using nucleic acid sequences that the researcher specifies (Dillon and Rosen, 1993). While cloning known DNA fragments (or those for which only partial nucleotide sequence information is available) has been accomplished through the widespread use of PCR, most researchers have not fully utilized the various applications of PCR technology. The absence of practical and highly effective cloning techniques has been a significant issue. Few techniques are effective and, thus, appropriate for a broad range of applications, despite the fact that numerous approaches have been published for the cloning of PCR-amplified DNA fragments. In this review, I go over new ligation-independent techniques for cloning PCR-amplified DNA and how they might be applied to different molecular biology and nucleic acid engineering techniques.

Ligation-independent cloning

Even though restriction enzyme digestion and ligation have come to be associated with cloning and recombinant DNA technologies, the initial description of gene cloning employed a different technique that did not involve restriction enzymes. The cloning of PCR-amplified DNA fragments presents unique challenges, which have led to the development of ligation-independent cloning techniques recently. Similar ligation-independent techniques for cloning PCR-amplified DNA fragments have been reported by two separate groups. Both techniques entail the production of lengthy (lG12 bases) projecting ends on PCR-amplified DNA, which are then turned into competent cells by annealing them precisely to complementary DNA sequences on the right vector.Aslanidis and de Jong (Aslanidis and de Jong, 1990) digested the 3' ends of PCR fragments to produce 5' protruding ends by using the 3' exonucleolytic capability of T4 DNA polymerase. The length of the overhang and degree of exonuclease digestion were then adjusted by appending to the ends of the PCR primers a particular sequence that is devoid of one nucleotide base. The enzyme uracil DNA glycosylase (UDG) is another technique for producing protruding ends for ligation-independent cloning of PCR products (Nisson *et al.,*1991; Rashtchian *et al.,* 1992). Using oligonucleotide primers with deoxyuridine residues inserted into their 5' tail, this approach is utilized. With the use of these primers, a deoxyuridine-containing sequence is added to the 5' ends of the PCR product. The PCR products had single-stranded 3' overhangs as a result of UDG's selective elimination of deoxyuridine residues. After that, these products can be annealed to a suitable vector that has complementary single-stranded ends, circularizing the vector and insert. After that, the recombinant vector can be effectively used to create competent *Escherichia coli* cells.

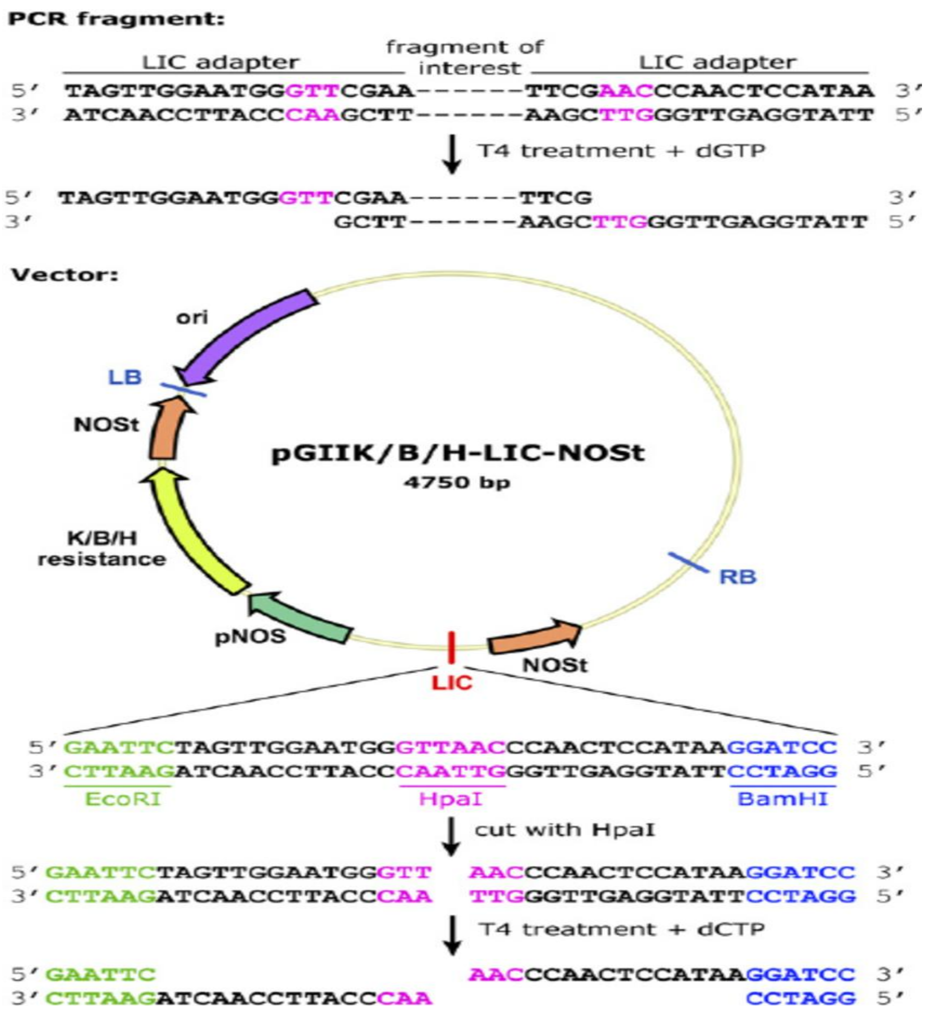

Fig 1:- LIC cloning procedure with modified LIC site (source:- 10.1104/pp.111.177337)

High-fidelity PCR and gene cloning

It has been demonstrated that *Thermus aquaticus* (Taq) DNA polymerase's low fidelity can cause mutations to be introduced into amplified DNA during PCR amplification (Eckert and Kunkel, 1991; Tindall and Kunkel, 1988). When significant amplification is needed from little amounts of template or from low-abundance mRNAs, this issue may get worse. There are two ways to improve fidelity: using a thermostable DNA polymerase with proofreading activity, or reducing the overall number of PCR cycles (Lundberg *et al.,* 1991). Cloning in as little as eight to ten cycles is possible using the UDG cloning approach because of its excellent cloning efficiency and nearly complete absence of vector background (Owen *et al.,* 1994).This feature of UDG cloning has been utilized to clone and express a number of restriction and modification genes, enabling high-fidelity amplification and cloning by PCR. By amplifying the relevant genes from bacterial genomic DNA after six to ten cycles of PCR, several restriction enzyme and methylase genes have been cloned (M Smith, personal communication). After 15 PCR cycles,(Booth *et al.,* 1994) cloned the genes encoding two neurotrophic factors directly from human genomic DNA. The great efficiency of UDG cloning made successful cloning possible even though the amplification products were generally invisible after 15 cycles of PCR. Cloned DNA fragments have been characterized after PCR and UDG cloning, showing that 'real' or authentic genes can be cloned and DNA sequences can be amplified accurately.

Generation of nested deletions

For many molecular biology applications, creating cloned DNA segments that show a nested set of deletions is an essential first step. This collection of DNA subclones can be used for gene walking, domain mapping, epitope mapping, and other functional investigations of genes in addition to DNA sequence analysis (Wang *et al.,* 1993). Nested deletions have been created via directional cloning of PCR-amplified DNA segments using UDG cloning and PCR amplification. (Witcomb *et al.,* 1993) describe this technique as random-primed anchored PCR (RPA-PCR), which is predicated on the use of random primers bearing a deoxyuridine-containing sequence at the 5' end region. These primers are used in conjunction with a DNA polymerase to copy the target template DNA at random, producing a succession of emerging fragments that have the deoxyuridine-containing sequence at their 5' ends (referred to as the 5' tail). When primers targeting the 5' tail and a specific region of the template are used to amplify such DNA fragments, PCR products that are "nested" and anchored at both ends are produced. Using UDG cloning, directional and selective cloning of these amplified pieces produces individual clones with nested deletions. Using a cloned portion of the Rous sarcoma virus genome, (Witcomb *et al.,* 1993) produced a variety of nested deletion clones with lengths ranging from 200 bp to 2500 bp, demonstrating the usefulness of this technique. Direct sequencing from the known areas of clones is suitable for the nested deletions that are generated. Using this technique, DNA sequences from cloned DNAs in plasmid vectors, h vectors, yeast artificial chromosomes, and potentially more complicated genomes can all be directly and selectively amplified and cloned. Other potential uses for this technology include chromosome walking, obtaining cDNAs for the 5' ends of mRNAs, identifying 3'- and 5'-flanking sequences, cloning transposon integration sites, deletion analysis of regulatory regions of eukaryotic promoters, and obtaining genomic sequences from cDNA sequences.

Site-directed mutagenesis using PCR and UDG cloning

An easy way to create 3' overhangs on PCR I segments is to employ oligonucleotide primers containing deoxyuridine in PCR. This feature provided the impetus for the creation of a technique for site-directed mutagenesis of DNA sequences based on PCR amplification and UDG application

(Rashtchian *et al.,* 1992). The process entails synthesizing two overlapping primers with the required nucleotide change(s), wherein deoxyuridine is substituted for some or all of the thymidine residues.Because the primers are made to have the required base change(s) in them and their complementary sequence in the opposite strand, the entire plasmid is amplified during PCR as a linear DNA fragment. When deoxyuridine-containing primers are added to the PCR product, the fragments' 5' end becomes vulnerable to UDG. When UDG is applied to these PCR products, deoxyuridine residues are removed, resulting in the production of 3' sticky ends. The overlapping nature of the primers utilized results in complementary 3'-protruding ends, which cause the PCR products to become circularized. After the circularized plasmids are transformed and repaired in vivo, new plasmid molecules are produced. These plasmid molecules are exactly the same as the parental plasmid in wild type, with the exception of the desired alterations.

If a plasmid does not contain the desired gene or if the plasmid is too big to be amplified completely, the desired gene can be amplified in two parts and then cloned using UDG. Using this method, mutagenesis is carried out by creating two overlapping deoxyuridine-substituted primers that have the necessary mutations. To facilitate UDG cloning into suitable vectors, each primer is employed in a separate PCR amplification along with a suitable5' or3' primer that contains deoxyuridine sequences. To create chimeric molecules with the required mutations, the amplification products are combined with the vector and UDG in a single tube. Competent *E. coli* cells are transformed directly using the circular chimeric plasmids that are produced. The intended mutation can be found in clones that carry the chimeric plasmid.

Engineering novel genes

Gene engineering is made easy and convenient with the UDG cloning process, which also offers a quick and easy way to clone PCR products. A technique for creating novel recombinant genes can be obtained through ligation of amplified DNA fragments and PCR amplification, as demonstrated by Higuchi *et al.*, 1988. There are numerous applications for this technique, known as "recombinant PCR," in molecular biology. By lowering the number of amplification cycles, the ligation of different DNA fragments utilizing UDG cloning technology has simplified the procedure and produced high-fidelity recombinant PCR. Human ciliary neurotrophic factor (CNTF) cloning was done using this technology by (Booth *et al.,* 1994). Since there is only one intron between the two exons that make up the CNTF gene, PCR was used to amplify each exon separately from the genomic DNA. Because deoxyuridine was used in place of thymidine in the PCR primers, primer deoxyuridine residues may be removed after amplification using UDG, producing single-stranded 3' overhangs. Thus, the full-length CNTF sequence was produced by assembling the various exons. DNA sequencing used to further characterize the cloned fragments revealed that the coding sequences for CNTF had been successfully cloned, indicating the creation of a clone that is comparable to a cDNA clone. A chimeric gene, BDNF, encoding brain-derived neurotrophic factor with the pre-pro sequence of nerve growth factor, was also created using a similar method.

PCR technology is now also applicable to the diverse family of antibody genes. This is possible because antibody genes contain conserved sequences in the 5’ and 3’ portion of the variable sequences, framework sequences and whole constant region sequences.

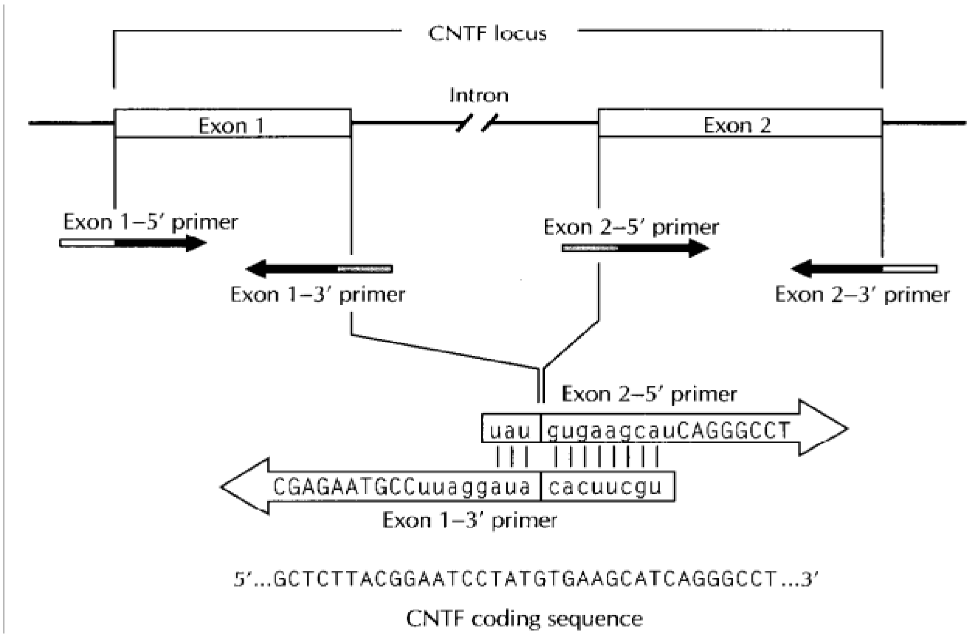

Fig 2:- Use of overlapping primers in which thymidine residues have been substituted with deoxyuridine for the generation of 3' overhangs and annealing of PCR products to create novel gene constructs.(Source:- Booth *et al.,* 1994)

Commonly used DNA extraction methods—their effects on DNA quality and PCR

A popular technique in agricultural biotechnology for figuring out the amount of GE in food and feed products is real-time qPCR. For the purpose of confirming compliance with legal requirements and confirming the existence or absence of a specific feature, particularly in the early stages of product development, trace amounts of DNA generated via biotechnology are frequently analyzed using qPCR. The quantity, quality, and purity of DNA in a sample all affect real-time qPCR amplification. A nucleic acid extraction method's goal is to separate DNA that is acceptable in terms of integrity, purity, and quantity for qPCR diagnostic applications (Terry *et al.,* 2002). High-quality DNA must be obtained in order to guarantee confidence in all later stages of the process of producing analytical measurements. The DNA extraction techniques that are frequently used in agricultural biotechnology for diagnostic purposes are reviewed in this section.

Future applications

PCR has seen a sharp rise in use in molecular biology throughout the last several years. This trend is anticipated to persist because of the ongoing usage of PCR in cutting-edge applications. The size of the fragments that can be amplified by PCR has recently increased, which is a development in DNA amplification technique. In order to amplify lengthy DNA fragments, a combination of Taq DNA polymerase (or a deletion derivative of Taq polymerase) and a DNA polymerase with 3' exonuclease activity is used in a PCR modification that was recently disclosed by (Barnes, 1994). This technique has been used to amp up DNA segments up to 35 kb in length. The same technology has also been used by Cheng *et al.,* 1994 to demonstrate amplification of single copy DNA sequences of up to 22 kb directly km human genomic DNA.

A number of PCR DNA fragments have been successfully cloned using the UDG cloning technique. Furthermore, this method can be used to link DNA fragments at almost any location in a DNA sequence, negating the necessity for restriction enzyme sites. This property makes it possible to quickly create new genes and DNA structures, greatly expanding the molecular biologist's and protein engineer's repertoire of possibilities.

Conclusion

In summary, Polymerase Chain Reaction, or PCR, is a basic method in genetic engineering that provides accurate and effective amplification of DNA sequences essential for a variety of uses. With unparalleled accuracy and speed, PCR allows scientists to modify and study DNA for a variety of purposes, including gene cloning, mutation analysis, and DNA sequencing. Biotechnological research is greatly aided by PCR's adaptability and dependability, which open doors to advances in environmental science, agriculture, and medicine. PCR is still a fundamental technique advancing knowledge and creativity in the field of molecular biology even as genetic engineering develops.

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ISSN : 2583-0910
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Peer reviewed
monthly newsletter

Article ID : 04/XII/26/1224

CONSERVATION AND IMPORTANCE OF RAMSAR WETLANDS: A FOCUS ON TAMIL NADU

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Abstract

This popular article highlights the significance of Ramsar Wetlands, with a special focus on Tamil Nadu's contribution to wetland conservation. Ramsar Sites, recognized under the Ramsar Convention, serve as crucial ecosystems for biodiversity conservation, water management and climate change mitigation. India, with 85 Ramsar Sites, emphasizes the critical role of these wetlands in maintaining ecological balance and supporting local communities. Tamil Nadu, with 18 Ramsar Sites, plays a leading role in preserving diverse wetland types. The Tamil Nadu Wetlands Mission aims to restore and conserve these sites through a combination of scientific approaches, public awareness and community-based conservation efforts. Wetlands ecological, economic and social importance is paramount and protecting these ecosystems is essential for sustaining biodiversity, supporting livelihoods and combating climate change.

Keywords: Ramsar Sites, Wetland Conservation, Biodiversity, Tamil Nadu Wetlands Mission, Climate Change Mitigation

Introduction

A **Ramsar Site** is a wetland of international importance designated under the **Ramsar Convention**, also called the "**Convention on Wetlands**." Named after the city of Ramsar in Iran, where it was signed in 1971 under UNESCO's auspices, the convention came into force in 1975. This intergovernmental treaty promotes national action and international cooperation for conserving wetlands and the sustainable use of their resources. Ramsar Sites are recognized for their ecological significance, serving as critical habitats for waterfowl, conserving biodiversity and representing rare/unique wetland types. As of February 2024, over 2,500 Ramsar Sites protect more than 2.5 million sq. km of wetlands, with 171 national governments participating in the convention.

Criteria for Ramsar Sites

A. Group A: Representative, Rare or Unique Wetland Types
- Criteria 1: Wetlands with rare, unique or representative examples of natural or near-natural types in a biogeographic region.

B. Group B: Conserving Biological Diversity

Criteria Based on Species and Ecological Communities
- Criteria 2: Supports vulnerable, endangered or critically endangered species or ecological communities.
- Criteria 3: Maintains biodiversity by supporting significant populations of plants or animals in a biogeographic region.
- Criteria 4: Provides habitat for species during critical life stages or refuge during adverse conditions.

Specific Criteria on Waterbirds
- Criteria 5: Regularly supports 20,000 or more waterbirds.
- Criteria 6: Regularly supports 1% of a waterbird species or subspecies population.

Specific Criteria Based on Fish
- Criteria 7: Supports significant fish populations, life stages or interactions contributing to biodiversity.
- Criteria 8: Serves as a vital food source, spawning ground, nursery or migration path for fish.

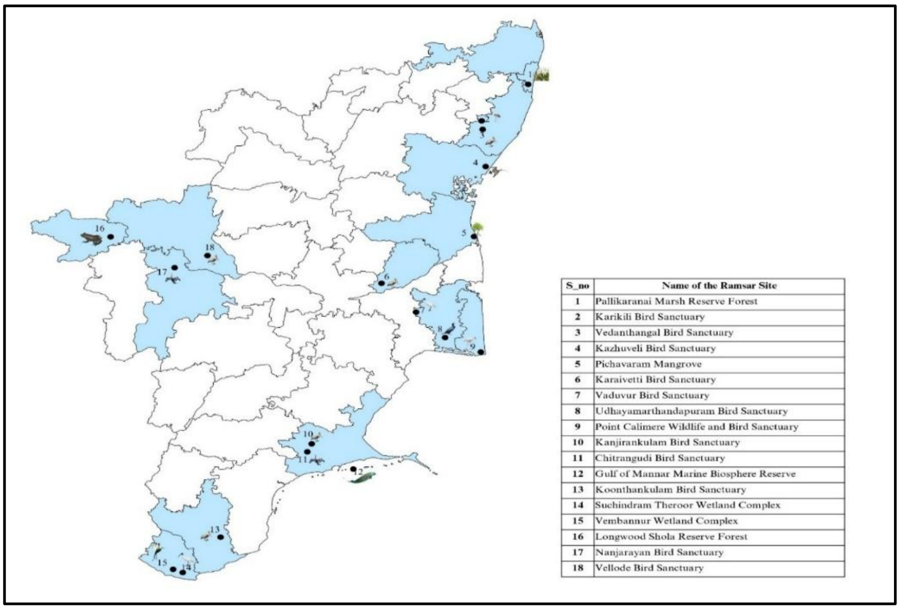
Specific Criteria Based on Other Taxa
- Criteria 9: Regularly supports 1% of a wetland-dependent non-avian animal species or subspecies population.

Ramsar sites of India

As of August 16, 2024, India boasts a total of 85 Ramsar Sites across its states and union territories, reflecting its rich wetland diversity and commitment to conservation. Tamil Nadu leads with 18 Ramsar Sites, followed by Uttar Pradesh with 10. Odisha and Punjab each have 6, while Madhya Pradesh and Jammu & Kashmir have 5 each. Gujarat and Karnataka contribute 4 sites each and Kerala, Maharashtra and Himachal Pradesh host 3 each. Bihar also has 3 Ramsar Sites, while Haryana and West Bengal have 2 each. States and union territories like Andhra Pradesh, Assam, Goa, Manipur, Mizoram, Tripura and Uttarakhand each have 1 Ramsar Site. Ladakh, known for its unique landscapes, has 2 designated wetlands. These sites underline the ecological and biodiversity importance of wetlands across India.

Ramsar sites of Tamil Nadu

Sl. No	Name of the wetland	District	Ramsar site number	Year of Declaration	Area
1	Point Calimere Wildlife and Bird Sanctuary	Nagapattinam and Tiruvarur	1210	19-08-2002	38500 ha
2	Gulf of Mannar Marine Biosphere Reserve	Ramanathapuram	2472	08-04-2022	52671.88 ha
3	Vembannur Wetland Complex	Kanniyakumari	2474	08-04-2022	19.75 ha
4	Vellode Bird Sanctuary	Erode	2475	08-04-2022	77.185 ha
5	Udhayamarthandapuram Bird Sanctuary	Thiruvarur	2476	08-04-2022	43.77 ha
6	Vedanthangal Bird Sanctuary	Chengalpattu	2477	08-04-2022	40.35 ha
7	Koonthankulam Bird Sanctuary	Tirunelveli	2479	08-11-2021	72.04 ha
8	Karikili Bird Sanctuary	Chengalpattu	2480	08-04-2022	58.44 ha
9	Pallikaranai Marsh Reserve Forest	Chennai	2481	08-04-2022	1247.54 ha
10	Pichavaram Mangrove	Cuddalore	2482	08-04-2022	1478.64 ha
11	Kanjirankulam Bird Sanctuary	Ramanathapuram	2486	08-04-2022	96.89 ha
12	Chitrangudi Bird Sanctuary	Ramanathapuram	2491	08-11-2021	260.47 ha
13	Suchindram Theroor Wetland Complex	Kanniyakumari	2492	08-04-2022	94.23 ha
14	Vaduvur Bird Sanctuary	Thiruvarur	2493	08-04-2022	112.64 ha
15	Karaivetti Bird Sanctuary	Ariyalur	2537	24-05-2023	453.7 ha
16	Longwood Shola Reserve Forest	The Nilgris	2538	24-05-2023	116.007 ha
17	Nanjarayan Bird Sanctuary	Tiruppur	0	14-08-2024	125.865 ha
18	Kazhuveli Bird Sanctuary	Villupuram	2548	14-08-2024	5151.6 ha



Source: Tamil Nadu Wetlands Mission

The Tamil Nadu wetlands mission

The Tamil Nadu Wetlands Mission, launched by the Government of Tamil Nadu with an allocation of Rs. 115.15 crores for the period 2021-2026, focuses on the ecological restoration and conservation of the state's wetlands. These wetlands play a critical role in water purification, groundwater replenishment, flood management and are vital carbon sinks that help mitigate climate change. The mission aims to identify, map and inventorize 100 wetlands over the next five years. Key objectives include preparing integrated management plans for these wetlands, notifying them under the Wetlands (Conservation and Management) Rules, 2017 and the Environment (Protection) Act, 1986 and undertaking eco-restoration based on scientific strategies. The mission also emphasizes public awareness campaigns, research, inventorying and promoting sustainable livelihoods, while encouraging stakeholder participation and community-based conservation approaches to protect wetland biodiversity. This comprehensive initiative highlights the state's commitment to safeguarding its wetlands, which are crucial for both the environment and the socio-economic well-being of millions of people.

Importance of wetlands

Wetlands are vital ecosystems that provide a wide range of ecological, economic and social benefits. They play a crucial role in maintaining water quality by filtering pollutants, replenishing groundwater and regulating the water cycle, which helps prevent flooding and droughts. Wetlands also act as carbon sinks, storing significant amounts of carbon and thereby mitigating climate change. They are rich in biodiversity, providing habitat for a variety of plant and animal species, including migratory birds and indigenous fish, many of which are threatened or endangered. Furthermore, wetlands support local communities by providing livelihoods through fishing, agriculture and eco-tourism. As crucial buffers against climate impacts, wetlands contribute to coastal protection by reducing the effects of storms and rising sea levels. Their importance in both environmental and socio-economic contexts makes wetland conservation essential for sustainable development and the health of our planet.

Conclusion

Wetlands are invaluable natural resources that provide critical ecological, economic and social services. They help maintain clean water, control flooding, foster biodiversity and store carbon, which is vital in the fight against climate change. Ramsar Sites, recognized globally for their significance, are key to preserving these areas. India's 85 Ramsar Sites, including 18 in Tamil Nadu, reflect the country's dedication to wetland conservation. Through the Tamil Nadu Wetlands Mission, the state is working to restore and safeguard these vital ecosystems, ensuring their role in both environmental protection and community well-being. Protecting wetlands is essential for sustainable development and climate resilience.

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/27/1224

IMPACT OF CLIMATE CHANGE ON THE SPREAD OF VECTOR-BORNE PLANT DISEASES

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Abstract
Climate change is significantly altering the dynamics of vector-borne plant diseases, which are major threats to global agriculture and food security. Rising temperatures, altered precipitation patterns, and extended growing seasons are driving the expansion of insect vectors such as aphids, whiteflies, and thrips, along with the pathogens they transmit. These changes exacerbate disease severity, expand geographic ranges, and create novel vector-pathogen interactions. Case studies, including outbreaks of Tomato yellow leaf curl virus and Citrus Greening, highlight the profound agricultural impact. Addressing this challenge demands integrated management strategies, climate-resilient crop varieties, and global collaboration to safeguard crops against climate-driven disease pressures.

Introduction
Climate change is one of the most pressing challenges faced by global agriculture, and its impact extends beyond droughts, floods, and extreme weather events. Among the subtler yet increasingly significant consequences is the effect on the spread of vector-borne plant diseases. These diseases, which involve plant pathogens transmitted by insect vectors, pose a substantial threat to crop production and food security. As climate change alters the environmental conditions that govern insect and pathogen populations, the incidence, severity, and geographic range of these diseases are likely to expand.

Vector-Borne Plant Diseases: An Overview
Vector-borne plant diseases involve the transmission of pathogens—viruses, bacteria, fungi, and nematodes—by insect vectors such as aphids, whiteflies, thrips, leafhoppers, and beetles. These vectors can efficiently transmit pathogens from infected to healthy plants, often across long distances. For instance, aphids are notorious for transmitting a variety of plant viruses, such as the Barley yellow dwarf virus, while whiteflies are responsible for spreading Tomato yellow leaf curl virus.

In such systems, the relationship between the vector, the pathogen, and the environment is complex and dynamic. Even minor environmental changes can significantly impact vector populations, pathogen virulence, and disease spread.

Climate Change and Its Impact on Vectors
Climate change is altering temperature, humidity, and precipitation patterns, which directly affect the life cycles, survival, and distribution of insect vectors. Some of the key ways climate change influences vector behavior include:

1. **Range Expansion**: Warmer temperatures allow insect vectors to expand into regions where they were previously unable to survive. For example, aphids and whiteflies that traditionally thrived in tropical and subtropical areas are now being found in temperate regions. As these

vectors colonize new areas, they bring with them pathogens that can infect previously unaffected crops.

2. **Increased Vector Activity**: Rising temperatures can accelerate the life cycle of many insect vectors, increasing their reproduction rates and population density. For example, aphids can develop and reproduce more quickly in warmer conditions, leading to more frequent pathogen transmission events.
3. **Extended Growing Seasons**: Longer growing seasons in some regions due to warmer temperatures can extend the window during which vectors are active. This prolonged activity allows more opportunities for vectors to feed on plants and transmit pathogens.
4. **Altered Migration Patterns**: Insect vectors such as whiteflies and thrips are highly mobile, and changes in wind patterns or weather systems influenced by climate change may enhance their ability to migrate over longer distances, spreading pathogens to new areas.

Impact on Pathogens

Climate change also affects plant pathogens themselves, both directly and through its impact on vectors:

1. **Pathogen Virulence**: Warmer temperatures and increased CO2 levels can affect the virulence of certain pathogens. Some pathogens may become more aggressive, leading to faster disease progression in infected plants. For example, the Tomato spotted wilt virus, transmitted by thrips, is more severe in regions with higher temperatures.
2. **Overwintering of Pathogens**: Milder winters in some regions may allow insect vectors and pathogens to survive through the colder months, increasing the likelihood of early disease outbreaks in the following growing season. This leads to a faster accumulation of infections across growing seasons, compounding crop losses.
3. **New Vector-Pathogen Interactions**: As vectors expand their range, they may encounter new pathogens and form novel associations. These newly established vector-pathogen pairs can give rise to outbreaks of previously unobserved plant diseases, compounding the challenges faced by farmers and plant health professionals.

Case Studies

1. **Tomato yellow leaf curl virus (TYLCV)**: Whiteflies, the vectors of TYLCV, have significantly increased their geographical distribution due to rising global temperatures. This has caused TYLCV to become a major threat to tomato production in regions where the virus was previously non-existent. Climate-induced changes in whitefly populations and behavior have resulted in more severe outbreaks in areas such as the Mediterranean, sub-Saharan Africa, and even temperate zones.
2. **Citrus Greening (Huanglongbing)**: Spread by the Asian citrus psyllid, Citrus Greening is a devastating disease affecting citrus production worldwide. Climate change is extending the geographical range of the Asian citrus psyllid, allowing the disease to spread into new regions, particularly in southern United States and parts of Asia. Warmer temperatures have also been linked to the increased survival and reproduction rates of the psyllid, leading to more frequent disease transmission.
3. **Whitefly Epidemic 2015-16 in Haryana and Punjab**: During the 2015-16 cotton season, an epidemic of whitefly infestation was observed in August across cotton-growing regions of Haryana and Punjab. The weather conditions in July 2015, with a maximum temperature of 33.88°C, a minimum temperature of 26.15°C, and relative humidity ranging from 67.49% to

88.13%, were ideal for whiteflies. Prolonged cloudy conditions and intermittent scanty rains from July to August created high humidity and hot weather. The whitefly populations exceeded the economic threshold of 6 adults per leaf, with higher insect infestation rates compared to the previous three years (2012-2014). By August, the virus caused leaf curl symptoms in more than 90% of the hybrids, except in early sown crops.

4. **Whitefly Populations and Apical leaf curl in potatoes**: Once minor pest *Bemisia tabaci* has seen a significant population increase in India, with numbers rising from an average of 11 whiteflies per 100 leaves in 1984 to 24.24 in 2004. This increase corresponds with a 1.07°C rise in average ambient temperature, suggesting that warming trends may exacerbate whitefly infestations in the Indo-Gangetic plains. Additionally, the surge in *B. tabaci* populations has coincided with the outbreak of a new viral disease known as Apical leaf curl in potatoes, attributed to a Gemini virus not previously reported to affect potato crops globally, introducing a new challenge to seed potato production in subtropical regions.

Implications for Agriculture

The spread of vector-borne plant diseases driven by climate change presents several significant challenges for agriculture:

1. **Food Security**: As the range and severity of vector-borne diseases increase, so do crop losses. This directly threatens global food security, particularly in regions that depend heavily on climate-sensitive crops such as cereals, fruits, and vegetables.
2. **Increased Use of Pesticides**: Farmers may resort to using more chemical pesticides to control vector populations. This can lead to negative environmental impacts, such as the development of pesticide-resistant insect populations, and increased residues in food and water sources, as well as negative impacts on non-target organisms like pollinators.
3. **Disruption of Ecosystems**: Changes in vector populations and pathogen transmission patterns can disrupt local ecosystems. Invasive insect species may outcompete native species, while novel pathogens can decimate native plant populations, leading to cascading ecological effects.
4. **Need for Integrated Management**: The traditional methods of pest and disease control may become less effective as climate change continues to influence vector dynamics. There is a growing need for integrated management approaches that combine biological control, cultural practices, and disease-resistant plant varieties with real-time monitoring and predictive modeling of climate-driven disease outbreaks.

Conclusion

The impact of climate change on the spread of vector-borne plant diseases represents an urgent challenge that calls for coordinated efforts from plant pathologists, entomologists, agronomists, and climate scientists. By understanding how climate variables affect vector behavior, pathogen virulence, and plant health, we can develop sustainable solutions that minimize disease outbreaks and protect global food systems. Investing in research and innovation to develop resilient agricultural practices will be critical in adapting to the challenges posed by this rapidly changing environment.

ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/28/1224

HEALTHY SOIL: THE SUPER STAR IN FIGHT AGAINST HUNGER AND CLIMATE CHANGE

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Abstract

Growing population and increasing living standards, industrial development, and urbanization are putting tremendous pressure on our finite natural resources. Extraneous changes such as global trading and climate change further complicate local challenges. Under such conditions, meeting sustainable development goals (SDGs) of no poverty, zero hunger and well-being, and achieving food security through climate resilient and sustainable development becomes a daunting task. This paper aims at highlighting the role of soil health as super star in fight against hunger and climate change.

Introduction

Roosevelt wrote "The nation that destroys its soil, destroys itself." His words still ring true today. Nearly all of the food we eat comes directly or indirectly from our soils, and without healthy soils, we will destroy our ability to feed ourselves. While much of the earth's soil has started to rebound, about one-third of soils worldwide are degraded mainly because we have not done our part to care for them. The biggest issue, especially in India where soil health is still declining, is that farmers have relied on the soil for decades to produce crops with limited return of nutrients back into the soil. Insufficient erosion control, improper fertilizer use, over tilling, growing the same crop year after year, and other unsustainable production practices have created unhealthy soils. This means that many foods are not as rich in vitamins and minerals because they get nearly all of their nutrients from the soil. This paper aims at highlighting the role of soil health as super star in fight against hunger and climate change.

Soil: The Foundation of Food

The most widely recognized function of soil is its support for food production. It is the foundation for agriculture and the medium in which nearly all food-producing plants grow. Plants rely on it to obtain the nutrients and water necessary for growth. Livestock, in turn, depend on plant matter for their sustenance, meaning 92% of our food originates from the soil. Healthy soil not only provides 15 of the 18 essential elements required for plant growth but also acts as a natural filter for clean water. Moreover, resilient soils enable crops to withstand drought, pests, and diseases, which is crucial for maintaining food security. It is estimated that 95% of our food is directly or indirectly produced on our soils. Healthy soils supply the essential nutrients, water, oxygen and root support that our food-producing plants need to grow and flourish. Soils also serve as a buffer to protect delicate plant roots from drastic fluctuations in temperature. Soil sits at the crossroads of these challenges. With soil holding 80 percent of the world's carbon found on land, it's one key tool for how we can both adapt to and mitigate the effects of climate change. Further, if we sustainably manage our soils, we could also increase food production by up to 58 percent. The key facts related to soil health and food security is are mentioned below (International year of Soils, FAO 2015).

- 95 percent of our food is directly or indirectly produced on our soils.
- A shortage of any one of the 15 nutrients required for plant growth can limit crop yield.
- By 2050, agricultural production must increase by 60 percent globally – and by almost 100 percent in developing countries – in order to meet food demand alone.
- It can take up to 1000 years to form one centimetre of soil. Sustainable soil management could produce up to 58 percent more food.

The Impacts of Soil Degradation on Food Production and Security

Soil degradation occurs when soils lose their ability to function effectively as resources for food production, water filtration, and ecosystem services. The main drivers of soil degradation include urbanization, intensive agriculture, deforestration, overgrazing, and industrial pollution. Polluted soils can lead to contaminated crops, while degraded soils result in reduced yields and compromised food security. This degradation makes communities more vulnerable to the impacts of climate change. Soil degradation manifests in various forms, including erosion, compaction, salinization, and contamination. As soil quality deteriorates, the challenge of sustaining food production becomes increasingly severe. Addressing soil degradation is essential for ensuring long-term food security.

Soil Health-A Perspective

The concept of soil health emerged from the term soil quality in the 1990s, and has been widely adopted. While soil quality and soil health are similar, they should not be used interchangeably as soil quality is related to soil functions or what it does, whereas soil health presents the soil as a finite and dynamic living soil resource, and is directly related to plant health. However, outside of the scientific literature, soil health and soil quality are frequently conflated. Soil health has become popularized as it invokes the idea that soil is an ecosystem full of life that needs to be carefully managed to regain and maintain our soil's ability to function optimally.

Governments and organizations are expressing growing concerns about soil health, driven largely by uncertainties of food security with an increasing human population and unpredictable effects of climate change. Although considerable literature and debate exist, there is discord around the question, what is a healthy soil? This is not surprising, given the complex roles the soil provides, from the range of food, fibre and medical products, hosting a biodiverse community, and supporting the water and nutrient cycles. While a consensus seems to suggest that a soil in good health should be able to provide goods and services in perpetuity, this does not define soil health, rather its provisioning functions. To explore the question, 'what is healthy?', we propose an analogy comparing indicators of human and soil health. For example, to identify the cause of a symptom, we compare the diagnostic pH in both humans and soil, demonstrating the similarities between the way human and soil health concerns are addressed. Additionally, we consider the context that necessitates health and use a set of holistic predictors to link human and soil health further. In humans, genetics express many traits and can predispose one to certain illnesses or diseases, in the same way, parent material, soil texture, and length of time exposed to weathering can inform a soil's capability and predisposition for certain habitats or uses. In both cases, science informs the state of health and appropriate management solutions. We posit the null hypothesis "the concept of human health cannot be applied to soil".

The Vital Role of Soil Health in Food Security

Food security is one of humanity's most critical challenges. It is achieved when everyone has "physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2006). However, as of 2024, over 3.1 billion people worldwide still cannot afford a healthy diet, and up to 783 million face hunger. In this post, w 'll explore the vital role of soil health in addressing these issues and the impact of soil degradation on food production. The concept of soil health is the cornerstone of 'Sustainable Agriculture' which may be defined as "an integrated system of plant and animal production practices having a site-specific application that will last over the long term" (Gold 2009)), and is aimed to recharge the soil with nutrients and water that are essential for crop production, minimize soil erosion and maintain soil biota (Brodt et al. 2011).

The transition to more sustainable agricultural systems, such as regenerative agriculture has been proposed in recent years so that soils may recover toward a healthier state aiming at the restoration of topsoil, enhancement of biodiversity, improvement of the water cycle, ecosystem services, and resilience to climate change with a range of management practices such as agroforestry, minimum tillage, cover-cropping, recycling of farm wastes and the addition of composted materials. Regenerative agriculture also helps increase soil C sequestration (i.e., SOM) thereby offsetting the GHG emissions. The suggestion of sustainable soil management and continual improvements may contribute to a more informed description of soil health as it aids in the description of what is a sustainable or 'healthy soil'.

Not only does sustainable agriculture play a crucial role in soil health, there is growing evidence suggesting that it may be linked to human health, as the soil also contains important nutrients, pathogens, as well as healthy microbes, natural antibiotics and medicines. In turn, better soil health is also the key to the global food supply, as healthy soil in combination with balanced, integrated nutrient management will result in optimum yield and good quality of produce, a necessity for human health – reinforcing the concept of 'One Health" (Keith et al. 2016).

Soil Health in Relation to Climate Change

The start of the present agricultural food production era may be considered the first instance of an increase in soil GHG emissions such that agriculture and associated land use changes are significant sources of CO2, CH4 and N2O emissions that contribute to climate change. As a result of climate change associated elevated temperatures, more frequent droughts and flooding further affect soil health by affecting crop production and increasing soil erosion and GHG emissions. Furthermore, soils can contribute to positive feedback loops resulting from increased SOM decomposition and soil GHG emissions. Thus, increasing emphasis is being laid on soil-centric climate change mitigation by developing soil C sequestration strategies and improved land use and management practices to decrease agricultural GHG emissions. Soils can mitigate some concerns of climate change as a result of greater soil C sequestration from increased productivity due to increased CO2, fertilization and a longer growing season. Better soil health, the result of higher SOC content, may also help mitigate climate change and its effects on other soil-ecosystem services, such as water quality, and sustain plant productivity with greater resilience to drought and flooding. However, to realize the potential for climate change mitigation through global soil management requires understanding cultural, political and socioeconomic contexts, and the ways in which widespread, sustained changes in practices can be successfully achieved. As such, there needs to be a greater level of engagement with the land users, who will need to implement the practices that abate GHG emissions and sequester carbon.

Adaptation and Solutions

In the past 50 years, advances in agricultural technology led to a quantum leap in food production and bolstered world food security. However, in many countries this intensive crop production has depleted the soil, jeopardizing our ability to maintain production in these areas in the future. With a global population that is projected to exceed 9 billion by 2050, compounded by competition for land and water resources and the impact of climate change, our current and future food security hinges on our ability to increase yields and food quality using the soils that are already under production today. Numerous and diverse farming approaches promote the sustainable management of soils with the goal of improving productivity, for instance: agroecology, conservation agriculture, organic farming, zero tillage farming and agroforestry. Food availability relies on soils: nutritious and good quality food and animal fodder can only be produced if our soils are healthy. A healthy living soil is therefore a crucial ally to food security and nutrition. Agroecology uses ecological theory to study and manage agricultural systems in order to make them both more productive and better at conserving natural resources. This whole systems approach to agriculture and food systems development is based on a wide variety of technologies, practices and innovations, including local and traditional knowledge as well as modern science. By understanding and working with the interactions between plants, animals, humans and the environment within agricultural systems, agroecology encompasses multiple dimensions of the food system, including ecological, economic and social. To enhance food security and soil health, adopting sustainable farming practices is essential. Key strategies include:

- **Crop Rotation**: Alternating crops to improve soil fertility and reduce pest build up.
- **Cover Cropping**: Planting cover crops to prevent soil erosion and enhance soil structure.
- **Agroforestry**: Integrating trees and shrubs into agricultural systems to improve soil health and biodiversity.
- **Reducing Chemical Inputs**: Minimizing the use of synthetic fertilizers and pesticides to prevent soil degradation.
- **Minimizing Tillage**: Reducing soil disturbance to preserve soil structure and organic matter.
- **Choosing Climate-Appropriate Plant Varieties**: Selecting crops suited to local environmental conditions.

Technological innovations can also play a significant role:

- **Precision Farming and Soil Monitoring**: Using data and technology to optimize soil management and crop production.
- **Biological Pest Control**: Employing methods such as drone-based pheromone dispersal to manage pests sustainably.
- **Micro-Irrigation**: Implementing efficient irrigation systems to conserve water.
- **Organic farming** is agricultural production without the use of synthetic chemicals or genetically modified organisms, growth regulators, and livestock feed additives. It also emphasises a holistic farm management approach, where rotations and animals play an integral role to the system. Soil fertility is the cornerstone of organic management. Because organic farmers do not use synthetic nutrients to restore degraded soil, they must concentrate on building and maintaining soil fertility primarily through their basic farming practices.
- **Conservation agriculture** practices have significantly improved soil conditions, reduced land degradation and boosted yields in many parts of the world by following three principles:

minimal soil disturbance, permanent soil cover and crop rotations. To be sustainable in the long term, the loss of organic matter in any agricultural system must never exceed the rate of soil formation. In most agro-ecosystems, that is not possible if the soil is mechanically disturbed. Therefore, one of the tenets of conservation agriculture is limiting the use of mechanical soil disturbance, or tilling, in the farming process.

- **Zero tillage** is one of a set of techniques used in conservation agriculture Essentially, it maintains a permanent or semi-permanent organic soil cover (e.g. a growing crop or dead mulch) that protects the soil from sun, rain and wind and allows soil microorganisms and fauna to take on the task of "tilling" and soil nutrient balancing - natural processes that are disturbed by mechanical tillage.
- **Agroforestry systems** include both traditional and modern land-use systems where trees are managed together with crops and/or animal production systems in agricultural settings. The combination of trees, crops and livestock mitigates environmental risk, creates a permanent soil cover against erosion, minimizes damage from flooding and acts as water storage, benefitting crops and pastures.

Technological innovations can also play a significant role:

- **Precision Farming and Soil Monitoring**: Using data and technology to optimize soil management and crop production.
- **Biological Pest Control**: Employing methods such as drone-based pheromone dispersal to manage pests sustainably.
- **Micro-Irrigation**: Implementing efficient irrigation systems to conserve water.
- **Nanofertilizers:** Nanofertilizers have many benefits, including:

Improved nutrient uptake: Nanofertilizers encapsulate nutrients and protect them from being lost through leaching or volatilization. This allows plants to absorb nutrients more effectively, which can lead to increased crop yields.

Sustained nutrient release: Nanofertilizers have a high surface area, which allows them to hold and release nutrients slowly and steadily in response to crop demand.

Reduced environmental impact: Nanofertilizers are applied directly to plant roots, which minimizes the amount of fertilizer that needs to be used. This reduces the risk of soil and water contamination, and helps to preserve soil fertility.

Improved soil quality: Nanofertilizers can help to improve soil quality.

Reduced pollution: Nanofertilizers can help to reduce soil leaching and pollution.

Nanofertilizers can help to transform how crops are grown, and can increase agricultural profits while reducing the environmental harm caused by conventional fertilizers.

Future perspective

Healthy soil has been shown to suppress the effects of pathogens, sustain biological activities, decompose organic matter, inactivate toxic materials, and recycle nutrients, energy, and water. On the other hand, degraded soils that are compacted or contain less SOM hold less water than healthy soil, thereby increasing the likelihood of floods and making them more susceptible to droughts, ultimately leading to economic losses. Among many benefits, keeping soils healthy will improve water availability, decrease nutrient inputs and increase pathogenic resistance.

With increasing knowledge and awareness of the role of soils in climate change and the mitigation of adverse impacts, national governments have begun to act on this important issue. In addition, the growing concerns about future global food security given an ever-increasing population and the continued degradation of soils have begun to ring alarm bells across nation-states.

The soil health concept fills an important stakeholder need in sustainable development by elevating the recognition of the role of soil in modern society. Farmers are mostly concerned with maintaining soil for productive purposes under variable conditions, whereas scientists like to know "why" and explain things by understanding relationships and processes. Nevertheless, through effective communication among all stakeholders, some of the anthropogenic changes impacting soil health may be reversed and soil health restored by adopting beneficial management practices and restoring soil biodiversity and resilience.

The main barrier to sustainable soil health practices is the economic cost. While practitioners are interested in maintaining good soil health by using best management practices (BMPs), stakeholders often cannot implement such BMPs due to economic constraints. Farmers are more likely to adopt those practices known to benefit the environment if they save on inputs without decreasing crop revenue. However, research shows that most sustainable agriculture practices that increase soil biodiversity and improve soil health are not economically viable in the short term for farmers. While farmers value the environment, they would certainly prefer to use sustainable practices if provided incentives, or at least compensated for any economic loss for adopting specific strategies.

There is a scientifically documented need for policy-makers, scientists, farmers, and foresters to collaborate and apply a holistic approach, share knowledge, promote soil health and integrate with plant, animal, and human health for controlling current and emerging infectious diseases, water quality, and food security issues. Additionally, there is a need to enhance the transfer of existing knowledge to and among farmers. Finally, efforts should be continued toward the development of a comprehensive soil health index that will benefit sustainable agriculture goals.

According to Dr. M. S. Swaminathan, Father of Green Revolution in India, "*Soil anaemia also breeds human anaemia. Micronutrient deficiency in the soil results in micronutrient malnutrition in people, since crops grown on such soils tend to be deficient in the nutrients needed to fight hidden hunger.*"

Conclusion

Soil provides 95% of the food we eat. However, the UN saysa third of soil globally has already degraded. When soil degrades its capacity to support animals and plants is diminished. It loses the chemical and biological qualities that sustain the millions of organisms living within it. The soil health and food security are deeply interconnected. Without healthy soil, we face significant challenges in maintaining crop yields and food quality. Soil degradation threatens the ability to produce nutritious food, impacting millions of people worldwide. To safeguard soil health and ensure global food security, we must embrace sustainable farming practices, leverage technological advancements, minimise food waste, and promote fairer resource distribution. On this World Soil Day 2024, we should pledge to protect natural resources (Land, water and biodiversity) to ensure food, nutrition and environment security.

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ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 04/XII/29/1224

A SCIENTIFIC GUIDANCE FOR GROWING FRUITS ON HOME GARDENING

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Abstract

This guide explores the essentials of home gardening, aimed at beginners and seasoned gardeners alike. It covers key components, including soil preparation, plant selection, and effective watering techniques. The guide also discusses choosing the right plants based on climate and space, focusing on mainly fruits that thrive in home gardens. Additionally, it addresses pest management strategies, promoting natural solutions to protect plants without harsh chemicals. Seasonal care tips ensure gardeners can effectively nurture their plants throughout the year, from planting to harvesting. With accessible information and practical advice, this resource empowers anyone to cultivate their own green oasis at home.

Introduction

Growing fruits in the home garden provides numerous benefits to families who can provide the necessary space and attention. Strawberries, raspberries, blackberries, blueberries, currants, gooseberries, and grapes are all major small fruits that can be cultivated well across Illinois. little fruits (so named because the edible fruit is produced on a little perennial plant) can be grown in limited space and are popular even on small city lots. Space constraints can be overcome by incorporating small fruit plants into shrub borders, screen plantings, arbors, hedges, or perennial gardens. The fruits grown in the garden will be valued for both their pleasant taste and their nutritional worth as providers of vitamins, minerals, and acids.

Selected fruit crops for home gardening

For home gardening small-fruit plants, choose high-quality varieties suitable for both fresh consumption and preservation. Many high-quality tiny fruit cultivars are unsuitable for commercial production, so your personal garden may be your sole source. Careful selection of early and late maturing types will result in a longer time of fresh fruit production. The use of multiple types also helps to ensure a successful planting, as one variety may perform very well in one region but not in another. Image-1

Image-1 (Home Gardening)

Popular Fruits

- Berries- Strawberries, Raspberries, and Blueberries.
- Tree Fruits- Papaya, Pomegranate, Plum, Cherry, Peaches, Pears, and Apple.
- Citrus Fruits- Lemons, Limes, and Oranges

Planning the fruits crops in home gardening

It is best to grow your fruit tree as close to your home as feasible. When space is restricted, fruit trees can be planted practically anywhere that attractive plants can be grown. Consider the tree's mature size when designing the planting area. Dwarf fruit trees make excellent attractive plantings. They bear fruit earlier than standard-size trees, take up less area, and are easier to prune and spray with equipment commonly available to the typical homeowner. Some nurseries sell dwarf pear, apple, peach, and cherry trees in a few different types.

- **Site Selection**

The importance of choosing the optimum place for fruit growing cannot be overstated. Proper air drainage is crucial. Cold air, like water, travels downhill. As a result, fruit buds on plants planted in a low spot are more likely to be destroyed than those on a slope. Choose late blooming cultivars for this location. Select soil that is deep, well-drained, and somewhat fertile. Most tree fruits thrive in rich, sandy or clay loam soil. Adequate water drainage is the most crucial soil attribute.

- **Variety Selection**

Planting multiple fruit kinds with varying maturation times might extend the harvest season. Varieties should be dwarf, disease resistant and tolerant to abiotic and biotic component. Commercial growers may offer more cost-effective options than growing some cultivars yourself during the season. Table-1,

Table-1 : Suitable Fruits Varieties for home gardening

Fruits	Varieties
Apples	Rome Beauty, Grimes Golden, Paulared, Stayman (red strain), Jonathan (red strain), Winesap
Pears	Harrow Delight, Moonglow, Harvest Queen, Orient
Grapes	Thompson Seedless, Perlette, Arka Vati,
Mango	Amrapali, Neelam
Peaches	Redhaven, Jerseydawn, Raritan Rose, Summer Pearl, Carolina Belle,
Cherries	Napoleon (Royal Anne), Vernon, Ulster, Hedelfingen, Windsor, Hudson
Banana	Dwarf Cavendish, G-9, Puvan, Nendran
Papaya	Pusa Nanha, Pusa Dwarf, Pusa Giant, CO-1, CO-2, CO-3, CO-4
Citrus	Pramalini, Vikram, Chakradhar, Sai Sarbati

- **Spacing in fruit trees for home gardening**

The bare minimum of acceptable spacing between fruit trees in home orchards is displayed in the following table. They should not be placed closer than the minimums suggested for optimal effects, though they can be placed farther apart if room permits. The planting's size is determined by factors like as site, family size, time constraints, pollination needs, and space. Table-2,

Table-2 : Spacing requirement of Fruit Trees

Mango (Amrpali)	2.5x2.5m
Banana (Dward Cavendish)	1.8x1.8m
Papaya (Pusa Nanha)	1.25x1.25m

Acid Lime (Vikram)	5x5m
Pear (Punjab Soft)	4x4m
Grapes (Thompson Seedless)	3x3m
Apple (Ambri)	4.5x4.5m
Straberry(Chandler)	45x60cm

- **Transplanting**

Choose healthy seedlings to guarantee success; they should ideally be started inside or bought from a nursery. Prior to transplanting, replenish the soil with organic matter, such as compost, which increases drainage and supplies vital nutrients. Select a good season to transplant, preferably in the early spring or fall when it's cooler outside. Make sure the hole you dig for the seedlings can hold their root system without being overcrowded. If the roots are bound, gently release them before planting the plant in the hole. Cover the plant with soil and press it down to remove any air pockets.

- **Manures and Fertilizers**

Manures, a high-quality source of organic matter and nutrients that improve soil structure, moisture retention, and microbiological activity. When we use mainly fertilizer primary element N, P, K is used, secondary elements Ca, Mg and S and other tertiary element used in fruit trees often do not exhibit improved growth or fruitfulness.

- **Irrigation**

Effective methods include drip irrigation, which directs water to the roots, and soaker hoses, which allow for progressive absorption. Hand watering using hoses or cans is also prevalent, although it is critical to water thoroughly and infrequently in order to promote robust root systems. Early morning watering reduces evaporation and lowers the danger of fungal illnesses. Additionally, mulch helps to maintain soil moisture and control temperature. A well-planned irrigation system promotes plant health and garden productivity, resulting in a healthy outdoor space.

- **Training and Pruning**

In home gardening, training and pruning are crucial techniques that improve plant health and increase fruit yield. Enhancing air circulation and light exposure while directing young plants to grow in a desired shape is known as training. Pinching back stems to promote bushier growth and using trellising for climbing plants are common methods. In contrast, pruning is eliminating branches or stems in a targeted manner in order to preserve plant size, improve growth, and get rid of disease. In addition to preventing overpopulation, routine pruning promotes the growth of stronger, more fruitful branches.

- **Mulching**

Mulching is the process of covering the soil surface in gardens and landscapes with a layer of material. Bark, leaves, and straw are examples of organic materials; gravel and landscape fabric are examples of inorganic materials.

- **Pest Management**

Borers: In times of drought when trees are not growing well, veneer or paper bands can also be useful in preventing wood borer infestations on tree trunks. It is recommended to apply paradichlorobenzene (P.D.B.) around the trees in all areas of Illinois at least every two years, as demonstrated in mid-autumn.

Mice: Trees can be protected from some mouse species by using poison bait, keeping debris away from tree trunks, and putting mesh wire protectors' bottom ends below ground level.

Rabbits: Rabbits prefer to eat the soft bark of young fruit trees, particularly those that bear apples and pears, when snow covers their usual food source. Therefore, it is important to cover these trees' trunks throughout the winter.

- **Harvesting of Fruits**

Most fruits are best eaten when they have ripened on the tree or plant. When the fruit colour of the strawberries, plums, brambles, cherries, and grapes is reached, they should be harvested. When the flesh is still firm but the ground colour, which underlies the hue of a fully ripened fruit, has become yellow, the yellow peach is ready. The ground should be white when the white peaches are ready. The fruit is now sufficiently ripe for storage, but allowing it to ripen for a few days at room temperature will make it more appetizing for eating right away. The harvesting of bush fruits takes a long time. Typically, gooseberries are harvested when they are completely green and the ideal size is reached. Unlike gooseberries, currants are permitted to mature.

Conclusion

Fruit gardening can improve your culinary experiences and yield abundant harvests if it is planned and maintained properly. Start small, try out a few different types, and relish the process of growing your own fruit garden.

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/30/1224

THE DYNAMIC RELATIONSHIP BETWEEN SOIL TESTING AND CROP RESPONSE

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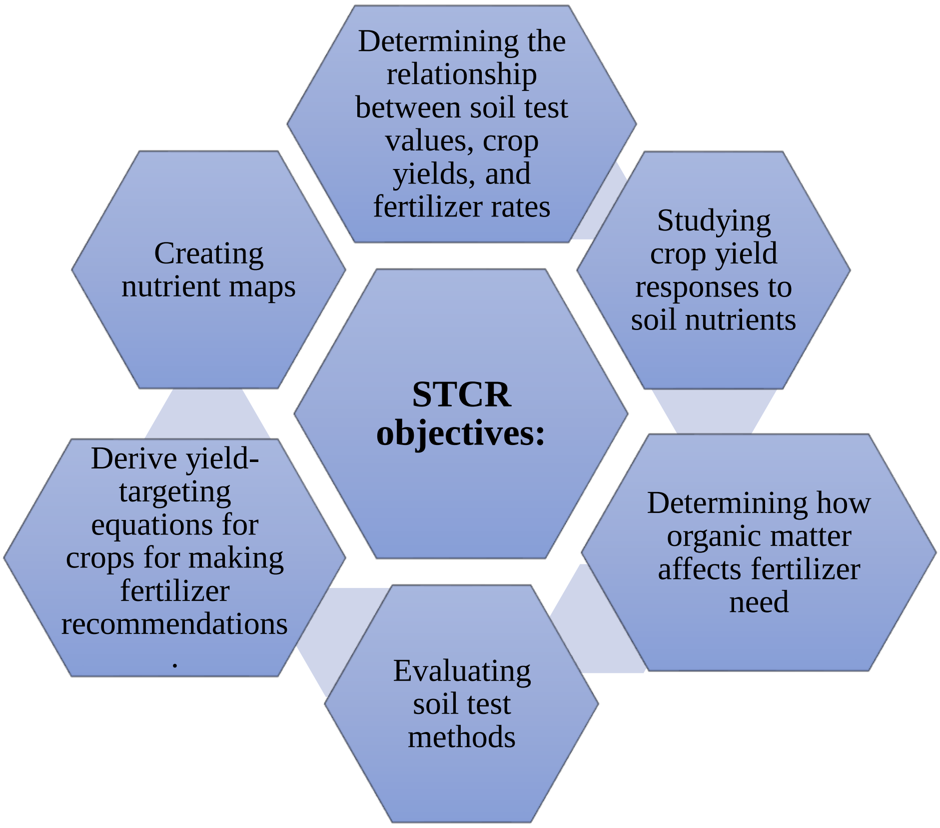
Introduction

In agriculture, fertiliser is a major investment, and applying the right amount is crucial for both agricultural profitability and environmental preservation. When farmers apply fertilisers incorrectly, they damage soil and water resources in addition to reducing agricultural production. Data on the optimal fertiliser amounts for each crop variety is crucial for increasing profitability across a range of soil and climate conditions. To ascertain these optimal fertiliser doses, the most suitable approach is the soil test-based integrated fertiliser recommendation system for various crops, which relies on soil testing and crop response research.

Soil Test Crop Response

The Soil Test Crop Response (STCR) method provides a quantitative foundation for fertiliser recommendations by evaluating soil fertility and crop-specific nutrient needs. It involves soil testing to determine nutrient levels and pH, followed by precise fertiliser and amendment applications tailored to optimise crop yield and quality. Also known as the Targeted Yield Approach, this method calculates the profit-maximising fertiliser dose needed for any crop based on soil test results. This approach is notably more quantitative, accurate, and meaningful compared to general recommended doses, soil test-based recommendations, and critical value approaches. STCR provides a specific target yield achievable through effective agronomic practices. The STCR approach seems to be a promising technology for maintaining increased productivity and ensuring improved soil quality within intensive agricultural systems. Under the All India Coordinated Research Project, the STCR technique is being developed in India for several crops in various agro-ecological zones. The STCR approach makes the assumption that, in order to achieve a specific yield, a linear relationship between grain production and crop nutrient uptake has been established. The calibrations are being created under STCR under integrated supply of organics and fertilisers, taking into consideration the nutritional contribution of soil, fertilisers, and organics. STCR supplies the fertiliser dosage in a quantitative and balanced manner.

Objectives of soil test crop response programme:



Advantages of STCR approach over blanket recommendations:

- Under ideal management circumstances, it guarantees that the intended yield target will be reached within 10% deviations.
- It guarantees that cropping systems maintain soil fertility at suitable levels for long-term crop production.
- STCR treatments can offer to wide choice of fixing appropriate yield targets according to the availability of resources and soil fertility, net benefits, and B:C ratios than blanket treatments.
- STCR takes into account the crop's needs and the nutrients present in the soil.
- Considering the relative capacities of crops and crop varieties to use nutrients from the soil and fertiliser, appropriate crop rotations can be implemented.
- High profit and responsiveness to applied fertilisers are ensured by the efficient use of fertilisers in accordance with crop requirements and soil fertility.

Targeted yield approach: needed

The concept of targeted yield is one strategy that falls within STCR. Troug introduced the idea of the targeted yield strategy in 1960. In order to create fertiliser recommendations based on soil tests for various crops, the ICAR in India launched the AICRP on STCR in 1967–68. A specific amount of the nutrients must be absorbed by the crop in order to achieve a given yield. Once the demand for a particular yield is determined, the efficiency of the soil's available nutrient pool and the fertiliser requirement can be used to estimate the fertiliser requirement. By striking a balance between fertilising the crop and the soil, the targeted yield approach offers a scientific foundation for balanced fertilisation. It's a helpful tool for applying fertiliser based on requirements. It's based on the idea that there's a linear relationship between the amount of nutrients a crop takes up and its grain yield.

Method of STCR:
Soil test-based fertilizer recommendations for different crops are obtain through the following two phases –

A. **Gradient Experiment:** An artificial soil fertility gradient is created by dividing the experiment field into strips and applying different levels of fertilizer to each strip. In this phase artificial soil fertility gradient is created at the experiment site by following the procedure:
   - Divided the experiment field into 3- 4 equal strips according to the size of the field.
   - In 1st strip – no fertilizers, 2nd strip – single fertilizer, 3rd strip – double fertilizer likely increasing fertilizer dose with an increase in the number of strips.
   - Grow exhaustive crop like maize, sorghum, and fodder crops.
   - Pre–sowing and post-harvest soil samples were collected from each strip and analysis.
   - Plant analysis after harvest of exhaustive crops.

B. **Test crop experiment:** Test crops are grown with varying levels of nutrients, organic manures, and absolute controls. After confirming the establishment of fertility gradients in the experiment field this phase of field experiment is conducted with the following procedure:
   - Each Strip is divided into a number of plots which is equal to treatments.
   - Initial soil sample is collected from each plot and analyzed.
   - The experiment layout as per statistical design.
   - Test Crop experiment is taken with different level fertilizers.
   - After maturity of crop to calculate yield from each plot.
   - Soil and plant sample is collected from each plot and analyzed.
   - Using the yield and nutrient uptake dose, soil test value, and applied fertilizer doses of treated control plots, the basic data viz. nutrient requirement (Kg / q) soil, fertilizer, and organic manure efficiencies (%) for making fertilizer recommendations can be worked out.

Conditions for yield targeting equations:
- Used for similar soils for particular agro – eco region.
- Maximum targets should not exceed 75 – 80 % of the highest yield achieved for the crop in the area.
- Fertilizer N recommendations for legumes should be the same as the general dose of the crop area.
- Adjustment equations must be made with experimental range of soil test value.
- If the targeted yield was achieved within 10 % variation, then the equations are found to be valid.

Conclusion
- Among the various methods of fertilizer recommendations, yield targeting is a unique one.
- Effective soil testing service to back up precise fertilizer use.
- Soil Test-based fertilizer recommendations result in efficient fertilizer use.
- The targeted yield concept gave the highest yield and the net benefit over farmer's practices showing superiority over other methods of fertilizer application.

- STCR (Integrated Plant Nutrient Supply – IPNS) for many crops not only helped in achieving higher yield targets but also in the maintenance and built up of soil fertility, soil test and productivity.

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed monthly newsletter

Article ID : 04/XII/31/1224

THE IMPACT OF CLIMATE CHANGE ON INSECT POPULATIONS

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Introduction

Climate change is one of the most pressing environmental challenges of our time, influencing ecosystems and biodiversity across the globe. Among the most affected groups are insects, which play critical roles in pollination, decomposition, and food webs. Rising temperatures, altered precipitation patterns, and shifting ecosystems due to climate change directly influence insect behavior, distribution, and survival rates. Insects, being ectothermic (relying on external temperatures to regulate their body heat), are particularly sensitive to temperature fluctuations, which can lead to changes in their metabolic rates, reproductive cycles, and migratory patterns.

Additionally, the shifting climates create new environmental pressures, such as spreading diseases and pests and losing habitats. These disruptions can have cascading effects on food security, agriculture, and natural ecosystems. Understanding the complex relationship between climate change and insect populations is essential for predicting future biodiversity trends and developing strategies for conservation and sustainable management of ecosystems.

Shifting habitats and distribution

One of the most significant effects of climate change on insects is the alteration of their natural habitats. As temperatures rise, insects are forced to adapt to new environmental conditions.

- **Temperature sensitivity**: Insects are ectothermic (cold-blooded), meaning their activity and survival are highly dependent on external temperatures. Warmer temperatures can cause species to shift their ranges toward higher altitudes or latitudes, where cooler conditions may be more suitable. For example, many alpine or northern insect species, like the mountain butterfly, are increasingly being pushed to higher altitudes as lowland areas warm up. Similarly, tropical species may migrate to cooler climates at higher elevations.
- **Changes in vegetation**: Insects often rely on specific plants for food, breeding, and shelter. Climate change can lead to changes in plant species composition, affecting the food supply for herbivorous insects and their predators. For instance, in forests, warmer temperatures may lead to an earlier leaf-out in trees, impacting the timing of insect life cycles and the availability of food.
- **Loss of habitats**: Increased droughts, flooding, and wildfires due to climate change threaten the habitats of insects. Wetland species, for example, are particularly vulnerable to drying wetlands, while fire-prone ecosystems disrupt the balance between insect populations and their environment.

Changes in migration patterns

Many insects, such as monarch butterflies, dragonflies, and locusts, exhibit migratory behavior, traveling vast distances in response to environmental cues like temperature and seasonal changes.

- **Altered timing**: Climate change has already altered the timing of migration for some species. Warmer spring temperatures can trigger earlier migrations, but this can lead to mismatches in the timing of food availability or breeding opportunities. For example, migratory birds may arrive before their insect prey is abundant, affecting the bird's survival and reproductive success.
- **Longer migration routes**: As insect populations shift to adapt to changing temperatures, some species may be forced to migrate longer distances in search of suitable habitats. This can strain the energy resources of migrating insects, leading to higher mortality rates or reduced population numbers.
- **Increased vulnerability**: Insects that rely on specific environmental cues to migrate, such as temperature or photoperiod (day length), may find these cues disrupted, potentially leading to disorientation, unsuccessful migrations, or failure to return to breeding grounds.

Changes in insect life cycles

Climate change can disrupt insects' intricate life cycles, finely tuned to environmental cues like temperature, day length, and seasonal patterns.

- **Earlier development**: Warmer temperatures can accelerate the development of insect larvae, pupae, and eggs. While this may result in faster population growth in some species, it can also cause mismatches between the insect's lifecycle and the availability of resources. For instance, if insect larvae hatch too early, they might face a shortage of food or shelter, leading to increased mortality.
- **Reduced synchrony**: Many insects rely on a synchronized life cycle to interact with other species in their ecosystem. For example, pollinators and plants often bloom and reproduce in sync. Climate change may cause a misalignment between insect activity and the availability of flowering plants, disrupting pollination and plant reproduction.
- **Disrupted diapause**: Diapause is a dormant state that many insects enter during unfavorable conditions, such as extreme cold or dry periods. Warmer winters may prevent insects from entering diapause at the right time, leading to higher mortality rates or improper development stages when conditions become harsher.

Impact on insect biodiversity

Insects are one of the most biodiverse groups on Earth, but climate change threatens to reduce this biodiversity in several ways.

- **Loss of specialist species**: Some insect species are highly specialized, relying on specific habitats, plants, or microclimates. As their preferred environmental conditions shift or disappear due to climate change, these species may struggle to survive or face extinction. For example, alpine species that rely on cold temperatures may face local extinction if temperatures rise beyond their tolerance levels.
- **Expansion of generalist species**: While specialist species may suffer, generalist species that can adapt to a wider range of conditions might thrive in a changing climate. This could lead to the proliferation of certain invasive species, such as the pine beetle or the brown marmorated stink bug, which may disrupt local ecosystems and further reduce biodiversity.

- **Declines in pollinators**: A significant concern with climate-induced shifts in insect populations is the potential decline of pollinators like bees, butterflies, and moths. A reduction in pollinator populations can have cascading effects on plant reproduction, leading to declines in plant biodiversity and reduced food security for humans and animals alike.

The ecological consequences

The impact of climate change on insect populations extends far beyond the insects themselves, affecting entire ecosystems.

- **Disruption of food chains**: Insects are a vital food source for many animals, including birds, reptiles, amphibians, and mammals. Declines in insect populations due to climate change can lead to food shortages for these animals, disrupting entire food webs. This can result in a decline in predator populations and a shift in ecosystem dynamics.
- **Soil health and decomposition**: Insects like ants, beetles, and termites play critical roles in breaking down organic matter and recycling nutrients in ecosystems. Climate-induced changes in their populations can disrupt these processes, leading to changes in soil composition and nutrient cycles that affect plant growth and ecosystem health.
- **Disease dynamics**: Insects such as mosquitoes and ticks are vectors for various diseases, including malaria, Lyme disease, and dengue fever. Changes in temperature and humidity can alter the distribution of disease-carrying insects, potentially leading to the spread of diseases to new regions. For example, warmer temperatures may enable mosquitoes to survive in areas previously too cold for them, increasing the risk of disease transmission.

Conclusion

Insects, often overlooked, are essential to the stability of ecosystems and human life. Climate change poses a significant threat to their populations by altering their habitats, life cycles, migration patterns, and biodiversity. The cascading effects on ecosystems and human agriculture and health make it crucial to address climate change and its impact on insects. Mitigation strategies to slow climate change, along with conservation efforts to protect insect habitats, are vital for maintaining biodiversity and ensuring ecosystem services that support life on Earth.

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ISSN : 2583-0910
Agri-India TODAY
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Article ID : 04/XII/32/1224

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Abstract

This content will be showcasing innovative farming practices from various farmers across Tamil Nadu. These farmers are leading the way with new techniques and ideas, inspiring others to pursue agriculture as a profitable profession. Through their years of experience and creative approaches, we'll also see how non-agriculture professionals are contributing to the field. This collection will motivate you to explore farming and its potential

Mr. Thiru Murthy

Thiru Murthy is from Sathyamangalam of Erode district. He farms 12 acres of land with his brother in Uppupallam. He tried over 6 jobs in 14 years but nothing worked out. He was interested in Agriculture in 2009 first grown sugarcane with other crops like tapioca and onions. He has learned from his mistakes about the price change and he made his own way to tackle it and succeeded.

In 2014 His mentor in agriculture has passed away: his father, as his father wish he planted Turmeric. He planted for half-acre and rest of the land with Coconut and Banana. He doesn't sell them to wholesale. He sold his first harvest 1ton quickly, 300kg of turmeric was powdered and retailed through his FB contacts. He named his venture "**Yer Munai**". In 2017 1.5 acre he used to cultivate Turmeric and every other year he leaves it fallow to give the time to land to nourish itself. Selling them to Mandi is a loss to him about ₹50/kg. The total production cost of turmeric is about 65k.Because of his implementation of Value addition of products +his venture he earns ₹ 50k/month. Turmeric is powdered and packed and sold for ₹80/kg. He found a method to increase the curcumin content of 8.6% which adds value & quality to his product.

As the Turmeric Cultivation is not a profitable one due to its price difference in imports and exports. Mr. Thiru Murthy found an alternate method to increase the income. He explains his techniques and methods to the farmer daily by posting in his FB account. By value addition he sells 3x from his normal prize. His Coconut is pressed and oil and soaps are made by his wife Gomathy. She produces Soaps of different organic herbs and makes 9 varieties this include Turmeric, Aloe Veera, Vetiver, Kuppameni, Arapu, Shikakai and Neem. She makes about 3k soaps /month.2020, Uzhavan foundation awarded a cash prize of ₹1lakh to Thiru for Organic Farming. Actor Sathyaraj also gave away the prize as a token of appreciating his success.

Mr. Parthasarathy

He is from Govindapuram, Tiruppur District. He increased the Rice Yield of CR1009, JKRH33, and COR-52. He increased his income with his new cropping system approach of (Rice-Maize-Onion) through drip irrigation.

We knew that Rice is cultivated through flooded irrigation method. But as the proverb; Necessity is the mother of Invention, the necessity of getting higher yield in the same piece of land just by implementing the new technique.

He joined with Netafim and TNAU and installed drip irrigation system to his field. Drip irrigation supply water and nutrient to the crop root zone.

He considerable saved the water about 40-42% compared to flood irrigation. The increase in yield /acre was about in a margin of 1100 kg. Under drip 5200kg/acre under flooded condition 4000kg/acre.

Total crop season cost ₹2.30 lakh/ha.
Total Gross Returns₹5.33lakh/ha.
Net Returns ₹3.2 lakh.

He won the 2015 Innovative Rice Farmer Award for the Large-Scale adoption of drip irrigation in Rice in the Amaravathy Sub-Basin in Tamil Nadu. He and 11 farmers who adopted drip irrigation for rice cultivation have set an example for every rice Farmer.

Mr.Selvaraj

This Farmer cultivates Groundnut, Tomato and Millets on his 2.75acres of land at Sesurajapuram village in Anchetty, Krishnagiri district. Invention of simple and innovative farm machines has made him a hero.

From Teenage, Mr.Selvaraj began to do experimenting with different farm equipment. He was fashioning simple farm machinery, with parts drawn from other farm machines and household articles. After Years of trial and error, the proud farmer now boasts of an array of innovative equipment, including for Sowing, Ploughing, Weeding and bed Former. The most appreciatble innovation is fan created to keep wild boars away, a land bedding machine and weeding equipment. They are made by DIY materials such as Cycle tyres, Blades, Wooden sticks etc.

The interesting part is this can be bought for ₹500. Usually farmers spend over ₹20k/season to hire workers for bed formation, sowing, weeding, earthing and other works.

The real Success for a Person, is someone inspires from them and do good in their Carrier. **Mr. J. Gabriel** a farmer from Sesurajapuram, shares that he has build a simple weeding machine inspired by Selvaraj’s equipments. He spents just ₹2000, making it and has been using it successfully for the past 4 years. **K.Chandran** a farmer of Anchetti Pudhur Village bought a weed removing equipment from Selvaraj on 2018. Pervious for weeding he could spend ₹1000/day for weeding, now his family members are enough with the Mastermind Selvaraj's weed remover.

Assistant Director of Horticulture, Thalli block, S. Arumugam said that Selvaraj is an inspiration for Small Farmers. His equipments are very useful for a small Farmer perviously workers need to be assigned for cultivation process which could later increase the production cost, minimizing their returns.

Now by cut-down the Labour-cost the small farmer could get enough returns from their small piece of land.

State Govt. should utilize funds from the rural employment guarantee scheme (MGNREGA) to make workers indulge in farming activity says Mr. Selvaraj.

Mr. Sundararaman. S.R

S.R. Sundararaman, a Farmer from Erode District grows variety of Crops in a completely natural and organic manner in his 10-acre farm since the early 90s.After 30 years engaged in chemical farming, he got awareness that the pest had increasing its resistance to the chemical and further application will affect the human health. He shifted to Organic Farming. He followed the guidance of Professor **S.A.Dabholkar**, who made him knew about the presence of beneficial microbes in the soil. These Microbes can be increased by adding Organic matter.

Mr. Sundaraman says that, "The Organic Farming first step is to replenish their region-specific natural properties. It's entirely location-specific, it depends on what crops are going to be farmed".

Totally around 10 acres of land, 1-1.5 acres of Coconut, 3 acres of turmeric, 2-4acres of tapioca and 2 acres of cattle feed. He also experiments the Moringa and Curry leaves.

The turmeric is a predominant crop on his farm. He trains farmer in Sathyamangalam Organic Farming Network about the basics of cultivating the crop organically with maximum Yield. In fact, for 7 years, this network has exporting nearly 160tons of Organic Turmeric which is around ₹12k/quintal. Chemically grown turmeric were ₹6-7k/quintal.

He is a pioneer of Organic Farming in South India, and received several awards and honours from the Govt. "Sristi Sammaan Award."

Sundaraman has also trained hundreds of regional cultivators and established a well-knit network of Orgainic farmers, He also travels around Tamil Nadu and Karnataka to find new plans and innovation to increase the yield through Organic Farming Says **Babu. P** an Agricultural Facilitator working with ICRA (International Centre for Development Oriented Research in Agriculture), Karnataka.

Mrs. Bindu. P

P Bindu from Bomminayakanpatti, Theni District. Started Farming after her two daughters joined School. Through her innovative Farming Methods and Enterprising nature, She sell value-added products like sun-dried vegetables and Culinary powders.

She cultivated Sugarcane on 5acre land, as we knew Sugarcane is a labour and cost-intensive crop. ₹80k/annum which is not enough for her daughter's fees. She uses to grow paddy+ sugarcane but still couldn't able to break the Poverty line. Through Self -Help groups (SHG) she learned about others techniques it was inspiring for her. She went to KVK and learned to make a value addition to her commodity, agriculture department distributed lentil and millet seeds.

In 2019 Bindu started growing Sorghum, Pearl Millet and Urad dal. Perviously she was growing corn and brinjal on her field. Through the KVK Workshop she gained knowledge on post-harvesting processing and packaging of the dried vegetables and found her own pesticides in Organic way. (Gineger+Garlic+ Pepper make up to 100 ml and mix it with 15 litre of water.)

2020, She started growing bananas, which take about 8-12 months for the harvest. She grows toor dal, tomatoes, Ladies finger through intercropping method. These crops will give harvest within 4 months thus providing as a supplementary income. It got a success and she experimented with coriander, bitter gourd and other vegetable.

She made sure that all her products are marketed and make use of every product, She got food safety certificates and Udyam certificates (mandatory registration for micro,small and medium enterprises) that leds to her own venture **"Pasumai"** in 2020 with other women under her. Pasumai sells more than 100 packets of their products/month.

Through her efforts her daughter has completed her master in engineering and younger daughter pursing Bsc. Nursing. She also train people to bring them forward. She was able to attain Financial Freedom. She also won awards for her innovative Farming methods.

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ISSN : 2583-0910
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Article ID : 04/XII/33/1224

ENHANCING AGRICULTURAL EDUCATION THROUGH BLENDED LEARNING: A FOCUS ON STUDENT-CENTRED APPROACHES

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Abstract
The advancement of technology has revolutionized agricultural education, rendering traditional teaching methods inadequate to meet the evolving needs of students and the demands of the modern world. Blended learning, a pedagogical approach that seamlessly integrates face-to-face instruction with online learning, has emerged as a promising solution. By employing technology, blended learning offers a flexible and engaging learning experience. This article explores into the core concepts of blended learning, highlighting its key features, benefits, and challenges. It examines various strategies, including the utilization of Open Educational Resources (OER), Massive Open Online Courses (MOOCs), and Learning Management Systems (LMS). Additionally, the article discusses innovative approaches such as Bring Your Own Device (BYOD), One-to-One computing, and the HyFlex model. By embracing blended learning, higher education institutions can significantly enhance student engagement, improve learning outcomes, and equip students with the necessary skills to thrive in the digital age.

Keywords: Agricultural education, Technology, Blended learning, Strategies

Introduction

Rapid changes brought about by scientific and technological breakthroughs, especially in information technology, characterize the modern period. For the higher education system to successfully handle new issues including handling enormous volumes of data, accommodating a growing student body, and addressing teacher shortages, it is imperative that it adopt these changes. For many years, traditional approaches to student training were successful because they concentrated on teaching certain information and abilities. This strategy, however, is no longer in line with the changing demands of the state and contemporary society. Despite their theoretical expertise, graduates frequently found it difficult to effectively handle real-world issues. The state therefore made the decision to close this gap by enacting additional educational provisions.

E-learning and blended learning are two examples of the creative teaching and learning approaches brought about by these scientific and technological advancements, and they are particularly beneficial in fields like research and personal growth. The global village has been effectively created by the information technology revolution, which has made it easier for people to share their knowledge and experiences with others and for learners to interact across a variety of platforms. In a 2021 circular, University Grants Commission promotes a blended learning approach, emphasizing how it can increase student involvement, improve teacher-student interactions, enhance learning results, and provide more adaptable learning settings. Forty per cent of each course should be taught online, with the other sixty percent being given offline, according to the text. According to NEP-2020, blended learning's main objective is "to render the process of learning not merely effective but additionally stimulating, uplifting, intriguing, and challenging for individuals."

Through the use of a variety of learning tools and communication channels available to learners as well as teachers, blended learning integrates in-person and virtual training. In essence, it combines traditional teaching techniques with e-learning, providing the versatility of distance learning while maintaining face-to-face communication. The learning environment produced by this method is richer than one that is entirely online or only in-person. With blended learning, students can select the learning method that best suits them, however some elements might be required. Teachers utilize this method because they wish to help students become used to technology, because they understand that certain students might find it difficult to handle a completely online course, or because they want to give extra help to those who might need it.

It is commonly acknowledged that implementing ICT is crucial to promoting educational reform and creating successful educational initiatives. However, the job of a teacher cannot be replaced by any current technology. With the help of the instructor, electronic devices can significantly improve the educational process. When it comes to keeping in touch with students and facilitating interactive classes, blended learning has outperformed traditional e-learning. This teaching strategy, which is frequently called a "hybrid" learning innovation, incorporates the best features of both traditional and cutting-edge teaching methodologies. In this model, technology is essential because it allows students to communicate virtually with their peers for collaborative knowledge-building and idea-sharing, which might be more constrained in in-person settings.

Conceptualizing blended learning

To improve learning outcomes and foster student involvement in virtual environments, blended learning incorporates in-person education with online components. According to research, blended learning causes higher education to adopt more interactive, student-cantered pedagogical approaches in place of traditional, one-way instruction. Informational assistance and process guidance are two essential components of instructional support in blended learning settings. Process advice has a good impact on social involvement; however informational support has a negative relationship with it. Course instructors can employ numerous support systems to encourage student participation and sociability within a mixed approach. Synchronous interactions using various e-learning tools encourage students to construct knowledge more effectively from a sociocultural standpoint.

Key Features of Blended Learning:

- Greater student engagement in the learning process
- Improved interaction between teachers and students
- Increased responsibility for personal learning
- Flexibility in time management
- Enhanced student learning outcomes
- Strengthened institutional reputation
- Flexible teaching and learning environments
- Support for self-directed and lifelong learning
- Expanded opportunities for hands-on, experiential learning

SWOT analysis of blended learning

Strengths	Weaknesses
• Personal accountability • Self-paced learning • Accessibility for students with disabilities • Primarily virtual learning • Safe learning and interaction	• Limited student engagement • Reduced interaction • Need for laboratory access • Software limitations • Restricted timing for interaction
Opportunities	**Threats**
• Advances in technology • Cloud-based capabilities • Support for multiple course management • Enhanced creativity • Integration of diverse software platforms	• Resistance to adaptation • Ensuring quality standards • Subject matter acceptance • Software selection and cost considerations • Individuals with technical difficulties

Blended learning approaches & strategies

Open educational resources (OER)

Any educational materials made available under an open license or in the public domain are considered Open Educational Resources (OER) by the UN. Learning resources that allow for (a) copying, (b) usage, (c) adaption, and (d) sharing are essential to promoting open knowledge and open access. These materials may include lecture notes, tests, films, animations, textbooks, syllabi, or other materials.

OER platforms: NMEICT (The National Mission on Education through Information and Communication Technology), NPTEL (National Programme on Technology Enhanced Learning), NDLI (National Digital Library of India), e-PG Pathshala.

Benefits of OER:

- It presents the chance to grant access.
- The cost-effectiveness in the provision of education.
- It generated a lot of discussion on knowledge-sharing and capacity-building strategies.

Massive open online courses (MOOC)

MOOCs are online learning platforms that offer a variety of courses with the goal of facilitating open access and widespread interactive participation. With the use of features like videos, study guides, tests and online assessments. MOOC seeks to deliver real-time education online. Through interactive discussion forums, MOOCs also give users access to interactive discussion sessions that foster a sense of community among instructors and students. MOOCs in agriculture and allied sectors: Khan Academy, Swayam, Udemy, PGDAEM-MOOCs (Post Graduate Diploma in Agricultural Extension Management- Massive Open Online Courses), agMOOCs.

Benefits of MOOC:

- By eliminating time and location restrictions, it is more effective than in-person instruction in classrooms.
- Many MOOCs are free or have very affordable fees, making education more accessible.

Learning management systems (LMS)

An online platform called an LMS is used to organize and distribute educational learning materials. Teachers can establish a course website and manage access with the help of learning management systems (LMS). They make it simple to upload and share resources, conduct online chats and debates, administer LMS tests and surveys, collect and go over assignments, and keep track of marks.

Examples: Moodle, Canvas, Google Classroom

Benefits of LMS:

- It provides a large range of resources that can improve the effectiveness of the course.
- All faculty members can upload and share any papers, videos, MP3s, or other materials pertinent to a specific class using an LMS that is placed in the cloud.

LMS	Vs.	WhatsApp
• Features like course management, content delivery, evaluation tools, and student tracking are all part of its specially made educational design. • Teachers can design courses, plan content, present lectures and resources, and evaluate student performance in this structured learning environment. • It is a systematic method for organizing educational resources and operations.		• This messaging software was created mainly for casual and private communication. • It is devoid of the educational resources and structured learning capabilities included in LMS platforms. • It has a lack of tools for systematic tracking student progress, managing courses and arranging materials for learning.

Challenges of blended learning

- Handling instructional complexity
- Structuring the design
- Managing roles and responsibilities
- Crafting a seamless learning experience
- Controlling expenses

Student identified challenges

- Expectation of reduced workload
- Limited time management skills
- Personal responsibility for learning
- Proficiency in using technology

Faculty-identified issues

- Time investment
- Faculty professional growth
- Developing new teaching and technology skills

Other innovative approaches

BYOD (Bring Your Own Device) Model:

Students are encouraged to assist their learning by bringing their own laptops, tablets, or cell phones to class under the BYOD approach. Using these devices' research, teamwork, and internet resource access capabilities, teachers incorporate them into assignments and activities in the classroom. By letting students use well-known technological resources in their education, this strategy encourages digital literacy, individualized learning, and student participation.

(One-to-One) computing model:
According to the computing paradigm, every student receives a personal gadget, like a laptop or tablet, to use both at home and at school. In addition to providing individualized learning experiences catered to the requirements and interests of every student, this guarantees fair access to technology. In addition to supporting anytime, anywhere learning, the paradigm encourages teamwork, innovation, and digital citizenship.

HyFlex (hybrid-flexible) model:
Students can participate in real-time online classes, attend classes in person, or view recorded class sessions asynchronously with the HyFlex paradigm. This takes into account different learning styles, timetables, and situations. Using technological tools like learning management systems and video conferencing platforms, instructors simultaneously train both in-person and online participants, encouraging communication and teamwork among all students.

Conclusion
Blended learning offers a promising avenue for enhancing student learning outcomes and preparing them for the demands of the digital age. By carefully integrating technology into traditional teaching methods, educators can create more engaging and personalized learning experiences. However, successful implementation requires a comprehensive approach that prioritizes both pedagogical and technological considerations. To maximize the benefits of blended learning, it is essential to provide teachers with adequate training and support. By fostering a collaborative learning environment and utilizing digital tools effectively, we can empower students to become active participants in their own education. Ultimately, blended learning has the potential to revolutionize higher education in India, but it necessitates strong leadership and a commitment to innovation.

Conflict of interest
Authors declare no conflicts of interest.

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/34/1224

INNOVATIVE WEED MANAGEMENT: THE ROLE OF NANO-HERBICIDES IN SUSTAINABLE AGRICULTURE

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Abstract

Weeds significantly threaten global biodiversity and agricultural productivity, contributing to substantial yield losses in key crops like rice, wheat, maize, and soybean. Innovative weed management integrates sustainable methods such as crop rotation, precision agriculture, biological control agents and cover crops to mitigate reliance on chemical herbicides. Nanotechnology has emerged as a transformative tool, enabling the development of nano-herbicides that offer precise, slow-release weed control while minimizing environmental harm and herbicide resistance. Nano-herbicides are categorized into organic, inorganic, and hybrid types, each leveraging advanced nano-materials to enhance efficacy, safety and target specificity. Despite numerous advantages, including enhanced input efficiency, reduced residues and environmental sustainability, challenges such as safety concerns, high production costs, limited research, and public acceptance hinder widespread adoption. Addressing these barriers is crucial to harnessing nanotechnology's full potential for sustainable weed management.

Introduction

Weeds are a major threat to biodiversity and agricultural productivity. The worldwide losses of attainable production of eight main food and cash crops like rice, wheat, barley, maize, potato, soybean, cotton and coffee due to pests (e.g., arthropod/insect pests, plant pathogens and weeds) (Chinnamuthu & Viji 2018). Developing and implementing novel, sustainable techniques to manage undesirable plant species (weeds) in horticultural and agricultural contexts is known as innovative weed management. By tackling herbicide resistance, environmental issues, and the high expense of chemical control, these techniques seek to lessen the dependency on conventional chemical herbicides. A variety of techniques, including crop rotation, robotics, precision agriculture, biological control agents and cover crops are used in innovative weed management to efficiently reduce weeds while fostering soil health, biodiversity, and long-term productivity.

Nowadays, nanotechnology represents a novel direction for sustainable agriculture development (An et al., 2022). By regulating the size of matter at the scale of 1 to 100 nanometres, nanotechnology has the potential to study, design, create, synthesize, and manipulate functional materials, devices, and systems to fabricate structures with atomic precision. The primary goals of nanotechnology in agriculture are to reduce inputs (pesticides, herbicides, and fertilizers), increase output (crop yields), monitor environmental conditions (sensors), and implement targeted action. Agricultural products can be produced, processed, stored, packaged and transported using nanotechnology in a variety of ways (Goswami et al., 2017). Recently, nano-enabled weed-controlling substances commonly referred to as nano herbicides, have demonstrated a potential use in sustainable agriculture. The plants only absorb a minimal amount of the herbicide.

Volatilization, adsorption, leaching, photodecomposition, chemical degradation, and microbiological breakdown are the methods by which the remainder is lost. When herbicides are used consistently, weeds become resistant to that specific herbicide (Heap, 2019). A slow-release nano encapsulated pre-emergence herbicide that eliminates weeds for the entire season without harming the environment can be created using the science of nanotechnology.

Types of nano-enabled herbicides

In addition to controlling the release of A.I. (active Ingredients) such as ions or biomolecules, nano-herbicides have demonstrated improved dissemination, adhesion and extended contact duration on the leaves (Peixoto et al., 2021). However, the physicochemical characteristics of nano-herbicides such as their size, shape, surface chemistry, concentration, etc. determine how they affect plants.

Organic nano-enabled herbicides: Organic nano-materials which can be based on complex macromolecules including dendrimers, proteins, lipids, polymers and lignocellulosic materials are excellent building blocks for creating nano herbicides. Overall, because polymers are biodegradable and biocompatible, they are frequently utilized in nano-enabled herbicide compositions.

Inorganic nano-enabled herbicides: These herbicides may be based on metal, mesoporous silica nano-particles, silica or another material. Some of these nano-herbicides have the ability to release ions, while others have the ability to encapsulate and release organic compounds under regulated conditions.

Herbicides enabled by hybrid nanotechnology: Components that are hybrid can potentially include the benefits of two or more components, including organic and inorganic, into a single structure. The characteristics, sizes, morphologies, and chemical compositions of these multipurpose nano-materials can vary widely. Additionally, hybrid nano-herbicides have the potential to enhance stimuli-responsiveness, traceability and target ability.

Advantages of applying nanotechnology to weed control

- Cutting-edge technology that improves accuracy to satisfy the high demand for meals.
- Improving yield and input use efficiency, cutting expenses, and minimizing crop loss. Biopolymers (cellulose and starch) can be used to create safe and eco-friendly nano-materials.
- Nano-particles are more soluble in suspension.
- Better targeted activity and increased surface area.
- Reducing the build-up of harmful residues and changing the effectiveness of microorganisms.
- Preventing the accumulation of resistance in weeds. Less environmental harm through comfortable and safe transportation (Xiang et al., 2017).

Present drawback of nanotechnology in weed management

Resolving the danger issue is the main obstacle to widespread use of this technology. And since *"technology-yes, but safety-must,"* it is crucial to evaluate the potential hazards and repercussions of employing nano-particles prior to implementing this technology. In comparison to other areas of nanotech application, the agricultural sector is still relatively marginal and has not yet been able to advance in the market to a higher degree. Due of its limited ability to load freight, nanotechnology is still unimportant and has not yet gained traction in the industry. As per the Namasivayam et al., (2014) few important constraint are given below-

- Nanoparticles exhibit unpredictable behaviour that could endanger life.
- Limited study on nanotechnology due to its toxicity and dangerous aspects.
- Applications of nano-materials in agrochemicals are currently being investigated challenges pertaining to production costs, evaluation criteria, registration regulations and public concerns need to be addressed.
- The materials used as magnetic nano-carriers can be recycled

Conclusion

By tackling important issues like herbicide resistance and environmental degradation, nanotechnology presents a promising strategy for transforming weed control. Sustainable agricultural objectives are met by nano-herbicides since they enable focused action and lessen reliance on chemicals. However, obstacles pertaining to cost, safety, public perception, and regulatory frameworks must be overcome for this technology to be successfully integrated. Scaling up its use requires more research, awareness-raising initiatives, and improvements in production efficiency. Adopting nanotechnology can help maintain biodiversity and environmental health while greatly increasing agricultural yield.

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ISSN : 2583-0910
Agri-India TODAY
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Article ID : 04/XII/35/1224

IS NUTRIENTS DELIVERY THROUGH FYM BETTER FOR SOIL HEALTH AND MUSTARD YIELD?

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Introduction

Brassica juncea L., or mustard, is a major oilseed crop that is grown extensively for its tasty leaves and oil-rich seeds. A significant issue in the region where Indian mustard is cultivated is the salinity of the soil and water resources. Abiotic stresses including soil salinity and sodicity, which restrict the availability of micro and secondary nutrients, particularly sulphur (S), zinc (Zn), iron (Fe), and boron (B), are the main cause of mustard's low productivity. Apart from these, lower level of organic carbon also agreviated the plant nutrient availability and uptake by crop plants. In mustard. optimizing crop growth, productivity, and nutritional quality requires effective nutritional management. Accordingly, the administration of micro and secondary nutrients determines the crop's potential yield in nutrient-deficient soil with low carbon content (Shukla et al., 2014; Ray et al., 2014). The bioavailability of nutrients in plant edible tissues fluctuates according to the amount needed by the plant and their availability or deficiency in the soil. Root-soil interaction enhances soil organic matter and retaining soil carbon and helps in the formation of stable soil aggregates optimal growth and development, of plants (Havlin 2020). Furthermore, a number of additional soil-related variables, such as soil chemistry, moisture, composition, pH, and compaction, influence how well plants absorb nutrients (Fageria and Moreira 2011). Nitrogen, phosphorus, and potassium are essential for energy metabolism, photosynthesis, water control, and disease resistance, and mustard needs a balanced supply of these key nutrients. Furthermore, mustard has a high sulphur demand, which is necessary for the plant to synthesise lipids and certain amino acids. Data showed that 42% of Indian soils now have insufficient zinc content, and as more marginal lands are subjected to intensive cultivation without adequate mineral replenishment, this deficiency is expected to get worse (Ghasal et al., 2017). As a result, micronutrient deficits in Indian soils have reduced the production and nutrient content of numerous oilseed crops, making them unfit for human consumption (Senthilkumar, 2018). Thus, a combination of micro- and macronutrient fertilisers can enhance soil health and nutrient transfer to the soil above plant parts for improved agricultural plant performance, growth, and yield (Fig. 1)

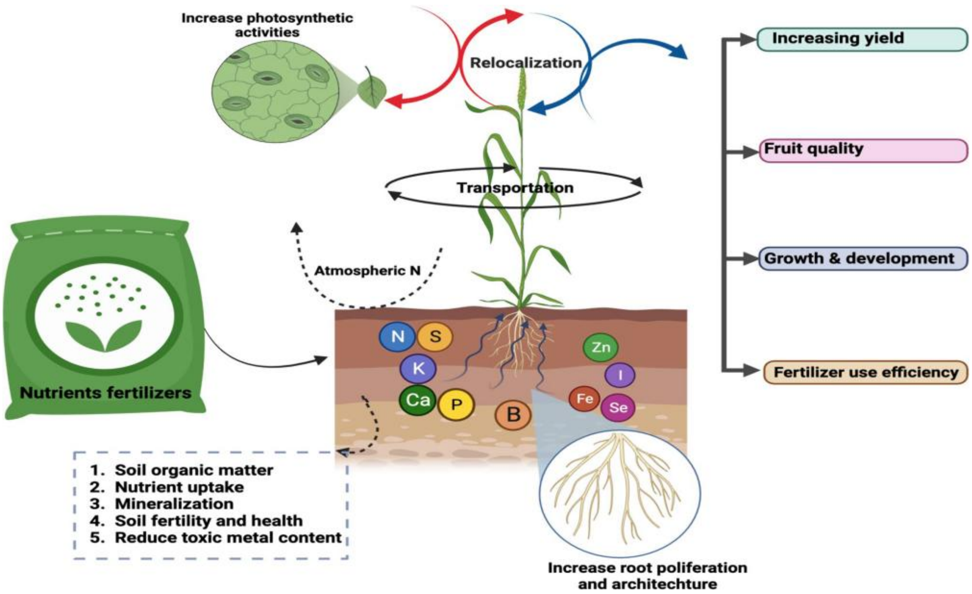

Fig. 1 Diagram showing the movement of macro and micronutrients and how they affect the health of plants and soil (Source: Jalal et al.,2024)

Agronomic biofortification is a tried-and-true technique that has been shown to be effective in fortifying multiple nutrients in a variety of crops. However, it has been observed that the efficiency of nutrient uptake and utilization varies among crops depending on various growing conditions, such as soil type, crop management, fertilizer type, etc. The effectiveness of agronomic biofortification has been further enhanced by the introduction of high specialty fertilizers with superior nutrient uptake efficiency and better nutrient translocation to the consumable parts of a crop plant, such as water-soluble fertilizers, chelated fertilizers, and nanofertilizers. One agronomic biofortification strategy for soil application that addresses the issue of declining soil health, nutrient availability, and yield levels in Indian mustard is the use of secondary and micronutrient-fortified FYM. This process, known as enrichment of FYM, fixed the inorganic Zn, Fe, B, and S that had been added externally into organically bound and naturally chelated forms. Chelated fertilisers are those in which a large organic molecule (called a chelator or ligand) envelops the nutrient ion, providing protection against oxidation, precipitation, and immobilisation. Chelated fertilizers have been shown to have better protection of nutrients from the soil conditions (pH, moisture, etc.) that cause immobilization or loss of nutrients via oxidation, precipitation, or leaching. Therefore, a sustainable approach to nutrient management, often involving the use of organic amendments such as manure, compost, or green manures, is essential. Organic amendments play a significant role in the nutritional management of mustard (*Brassica juncea L.*), enhancing soil fertility and providing essential nutrients in a sustainable way. The importance of agronomic biofortification for global food and nutritional security has been reaffirmed by this recent technological developments as well as a greater understanding of mineral micronutrient nutrition. Micronutrient-enriched fertilizers are used in agronomic biofortification, which is a quick and easy way to improve the nutritional quality of the crop. Eating these crops also improves human nutrition status (Cakmak and Kutman, 2017).

FYM enrichment with nutrient

For Zn, Fe, B, and S enrichment, locally sourced organic materials such as farmyard manure (FYM) were utilized. Sixty days before to their application in mustard (IJ-31), the enrichment procedure was initiated. A known amount of FYM was filled in the 1.5′ x 1.5′ × 1.5′ pre-dug pits. Solutions of $ZnSO_4.7H_2O$ equivalent to 2.5 and 5.0 kg Zn ha^{-1}, $FeSO_4.7H_2O$ equivalent to 5.0 and 10 kg Fe ha^{-1}, $Na_2B_4O_7.10H_2O$ equivalent to 1.0 and 2.0 kg B ha^{-1}, SSP and bentonite S corresponding to 10 and 20 kg S ha^{-1}, were delivered through 500 kg ha^{-1} well mixed FYM. After mixing with various nutrient sources, the organic material's moisture percentage was maintained at around 70 percent for the duration of the enrichment process. As starting inoculums of microorganisms, 1% cow dung slurry was added to the compost to increase the microbiological activities and improve the natural composting process. A polythene sheet was placed over the pit, and it was left to decay. The periodical samples were taken from the pit for determination of water soluble Zn, Fe, B and S content, when the value of water soluble nutrients appeared to be more or less constant and the enrichment process was considered as complete. Within six to seven weeks, the process was determined to be nearly finished. Total Zn, Fe, B, and S contents in the FYM employed for enrichment were 66, 1200, 2.4 mg kg^{-1}, and 0.24%, respectively (Table 1). Following enrichment under various levels of micro and secondary nutrients, Table 2 showed the Zn, Fe, B, and S contents in FYM and their enrichment efficiency.The test crop, Indian mustard variety DRMR IJ-31, was grown in accordance with suggested agronomic techniques.

Table 1. Nutrient composition of farm yard manure (FYM) used for nutrient fortification

Nutrients	Content
N (%)	0.54
P (%)	0.23
K (%)	0.57
S (%)	0.24
Fe (mg kg^{-1})	1200.00
Zn (mg kg^{-1})	66.0
B (mg kg^{-1})	2.4

Table 2. Total nutrient content of FYM before and after enrichment and nutrient enrichment efficiency

Organics / Nutrients	En-$Zn_1Fe_1B_1S_1$		En-$Zn_2Fe_2B_2S_2$		Enrichment efficiency (%)	
	Nutrient content in FYM	**Nutrient content after enrichment**	**Nutrient content in FYM**	**Nutrient content after enrichment**	**En-$Zn_1Fe_1B_1S_1$**	**En-$Zn_2Fe_2B_2S_2$**
S (%)	0.24	1.66	0.24	3.39	74.00	79.95
Fe (mg kg^{-1})	1200.00	17534	1200.00	28813	79.70	90.04
Zn (mg kg^{-1})	66.0	3850	66.0	8815	76.00	87.00
B (mg kg^{-1})	2.4	1442	2.4	3082	72.01	77.00

Studying the effects of nutrient delivery through nutrient-enriched organics and routinely used organics, i.e. FYM without nutrient-enrichment, was done using the recommended dose of NPK (80-40-40) in conjunction with FYM at 500 kg ha^{-1} as a control. The FYM was fortified with Zn, Fe, B, and S at the rate of 2.5 kg Zn + 1 kg B + 5 Kg Fe + 10 kg S En- FYM @ 500 kg h^{-1}(En-$Zn_1Fe_1B_1S_1$) and at the rate of 5 kg Zn + 2 kg B+ 10 Kg Fe + 20 kg S En- FYM @ 500 kg h^{-1} (En-$Zn_2Fe_2B_2S_2$). Each plot received urea, SSP, and MOP as a basal dose, which supplied half of the suggested nitrogen (40 kg ha^{-1}) and the full amount of phosphorus (40 kg ha^{-1}) and potassium (40 kg ha^{-1}).

Summary

The yield and nutrient content of different oilseed crops have declined due to micronutrient deficits in Indian soils. In addition to this, the low crop productivity in the mustard-growing region is mostly caused by abiotic factors such soil salinity and sodicity, which also reduce the availability of micronutrients like Zn, Fe, B, and S availability in the soil. As a result, judicious management of plant nutrients in these soils is just as crucial as soil reclamation. In order to reduce nutrient deficiencies in arid and semi-arid regions that get saline water irrigation, micronutrient-enriched FYM may be a useful tactic. It also aids in maintaining minerals in their naturally chelated state, which improves nutrition over extended periods of time and increases yields. The results showed that the maximum B:C ratio (4.22) was achieved with seed yield of 28.72 q ha^{-1} when fortified FYM including Zn, Fe, B, and S at the rate of 2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S En- FYM @ 500 kg h^{-1}. Additionally, the single practice of FYM fortification with secondary and micronutrients boosted stover and seed yield by 16.44% and 15.57 percent, respectively, compared to straight application. In the dry and semi-arid northwest of India, in the states of Rajasthan, Gujarat, Haryana, and portions of Uttar Pradesh and Madhya Pradesh, this research may yield a useful technique for raising mustard production.

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ISSN : 2583-0910
Agri-India TODAY
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Peer reviewed
monthly newsletter

Article ID : 04/XII/36/1224

DOUBLING FARMERS INCOME GOVERNMENT INITIATIVES STATUS AND ACHIEVEMENT

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ABSTRACT

India's agriculture, contributing 17.1% to GVA and supporting 70% of rural households, faces challenges of low farmer income and agrarian distress. To address this, the government launched initiatives in 2016 to double farmers' income by 2022 through strategies like productivity enhancement, diversification, and improved market access. Programs such as PM-KISAN, PMFBY, and higher MSPs have provided support, but challenges like debt and limited adoption of advanced techniques remain. This study reviews these policies and highlights innovative approaches, including smart and climate-smart agriculture. Results show progress in risk mitigation and income support, but further efforts are needed to enhance financial inclusion, sustainable practices, and technology adoption. Achieving this ambitious goal requires integrated reforms, investments, and continuous evaluation. In conclusion, while challenges persist, focused interventions and collaborative efforts can pave the way for sustainable agricultural growth and better farmer livelihoods.

Keywords: Doubling Farmers Income, Government initiatives, Status and Achievement.

Introduction

The Indian agriculture industry contributes significantly to the country's economy, contributing around 17.1% of GVA (Balkrishna et al., 2021). Agriculture plays an important role in generating employment and livelihood opportunities to around 70% of rural families in India, that result in twice the amount of economic development as any other option (Gills and Sharma, 2021). Efforts to improve agricultural productivity and ensure food security have been ongoing, but many farmers are leaving the sector due to low income. To address this problem, the Indian government formed a committee in 2016 to identify problems and develop strategies for doubling the income of farmers by 2022. The goal of doubling farmers' income is to increase profits through increased productivity, crop diversification, cost reduction, market accessibility, value addition, low-interest loans, crop insurance, and the development of rural infrastructure. Various programs like the PM-KISAN scheme have been introduced to support this goal, along with innovative practices such as advanced farming techniques and climate-smart agriculture (Balkrishna et al., 2022). However, challenges remain, and this study provides recommendations to inform policymaking and advance the 'doubling farmers' income' initiative.

Issue of lower farmer income

The agricultural sector is a dynamic system of entrepreneurship in India. On the one hand, it is as competitive commercially as the global market, but on the other, direct profit-chain share amounts to very less for farmers. In any case, the system of established suppliers reduces the maximum profit share under unconstrained political control, which occasionally pays farmers less than the cost of production.

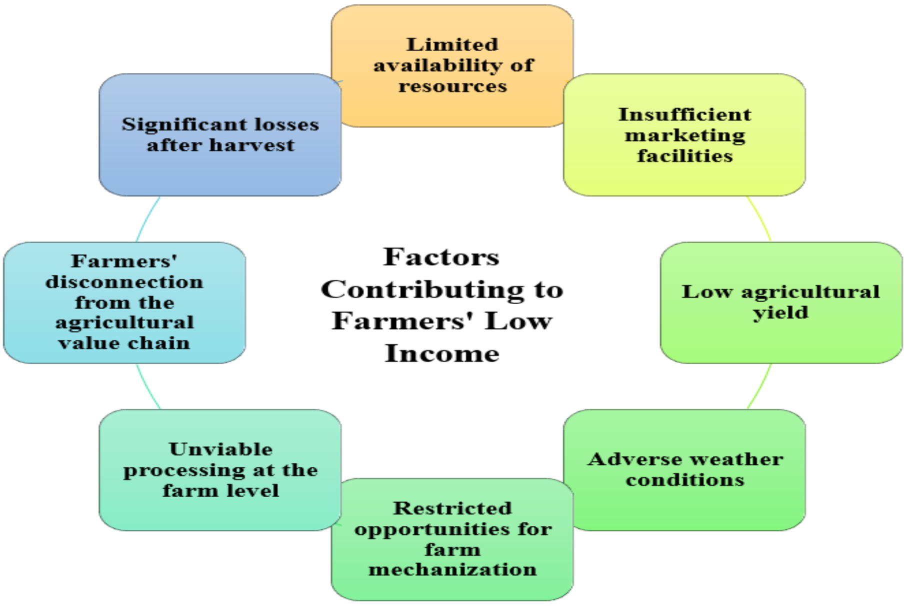

Figure 1 Issue of lower farmer income

The vicious result of low farmer income

Farmers with low incomes are forced to borrow money at high interest rates from money lenders in order to carry out agricultural activities as well as fulfill family and other social expenses. However, failure of crops, low productivity, and profitability prevent them from repaying their debts. The burden of debt gets so much that they are driven to commit suicide. Thousands of farmers committing suicide throughout Indian states explains the country's poor agricultural situation (Kambali, 2021).

Figure 2 The vicious result of low farmer income.

Need to double farmers' income

Previously, India's agricultural development policy has been largely focused on increasing agricultural output and enhancing food security. The total consequence has been a 45% rise in per capita food output. That's making India not just food self-sufficient on an aggregate basis, but also a net food exporter. The policy did not clearly identify the need to increase farmer income and did not include any practical measures to increase farmer wellbeing. Low absolute income, as well as widening and growing economic gaps between farmers and non-agricultural workers, were important sources of agricultural distress in the country during the 1990s, which grew especially serious in some years. The country additionally witnessed a significant increase in the number of farmer suicides between 1995 and 2004; losses from farming, shocks in farm revenue, and lower farm income were cited as major contributing factors. A growing number of cultivators, especially younger ones, are quitting farming due to low and unstable farm income, which is also decreasing enthusiasm in farming and farm investments and have a negative impact on the agricultural future of the nation.

Strategies for doubling income

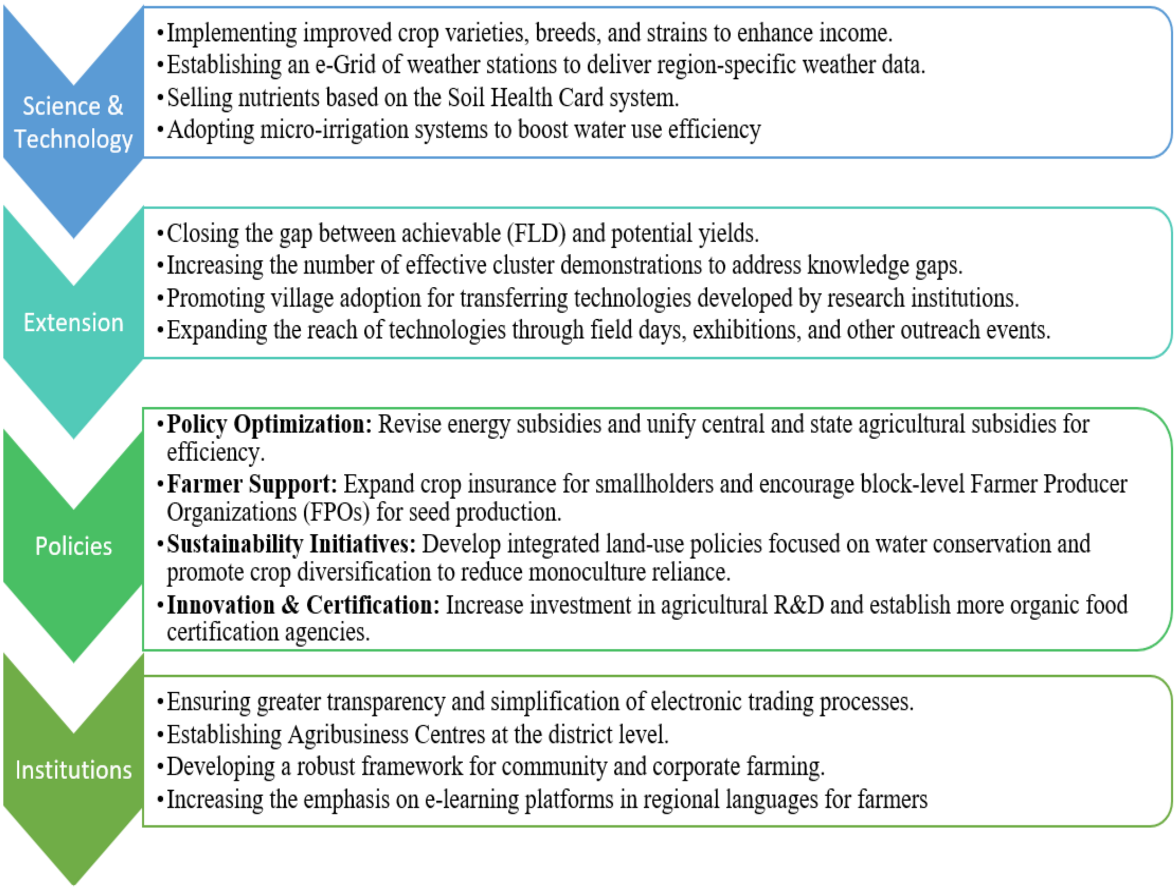

Figure 3 Strategies for Doubling Incom

Government initiatives for improving farmers' income

According to the strategy, the government has introduced and implemented a variety of policies, reforms, developmental projects, and projects aimed at increasing farmer incomes, either directly or indirectly. This consists of:

1. Unprecedented enhancement in budget allocation

In 2015-16, the Ministry of Agriculture and FW (including DARE,DAH&F) received just Rs. 25460.51 crore in budget allocation. This has grown by more than 5.44 times, reaching Rs. 1,38,550.93 crore in 2022–23.

2. Income support to farmers through PM KISAN

PM Kisan is a Central Sector project fully funded by the Government of India. The funds will be deposited immediately to the beneficiaries' bank accounts.PM-KISAN, an income assistance initiative, was launched in 2019 and provides Rs. 6000 per year in three equal installments. More than Rs. 2 lakh crore has been distributed so far to about 11.3 crore qualified farming families.

3. Pradhan Mantri Fasal Bima Yojana (PMFBY)

Six year - PMFBY was launched in 2016 addressing problems of high premium rates for farmers and Reduction in sum insured due to capping. In past 6 Years of implementation – 38 crore farmer applications has been enrolled and over 11.73 crore (Provisional) farmer applicants have received claims. During this period nearly Rs. 25,185 crore were paid by farmers as their share of premium against which claims of over Rs. 1,24,223 crore (Provisional) have been paid to them. Thus, for every 100 rupees of premium paid by farmers, they have received about Rs. 493 as claims.

4. Institutional credit for agriculture sector

It increased from Rs. 8.5 lakh crore in 2015-16 to a target of Rs. 18.5 lakh crore in 2022–23. Animal Husbandry and Fisheries farmers can now take use of concessional institutional financing through KCC at 4% annual interest rate to address their short-term working capital needs. Since February 2020, a specific initiative has been launched to provide concessional institutional credit, with a focus on reaching all PM-KISAN beneficiaries via Kisan Credit Cards (KCC). As of 11.11.2022, 376.97 lakh new KCC applications have been sanctioned, with a credit above of Rs. 4,33,426 crores as part of the program.

5. Fixing the minimum support price (MSP) at one and a half times the cost of manufacturing

From 2018-19, the government increased the MSP for all mandatory Kharif, Rabi, and other commercial crops, requiring a return of at least 50% above the all-India weighted average production cost. The MSP for paddy (common) has risen to Rs. 2040 per quintal in 2022-23, up from Rs. 1310 in 2013-14. MSP for wheat increased from Rs. 1400 per quintal in 2013-14 to Rs. 2125 per quintal in 2022–23.

Sources of Growth in Farmers' Income

Doubling real income of farmers till 2022-23 over the base year of 2015-16, requires annual growth of 10.41 percent in farmer's income. This implies that the on-going and previously achieved rate of growth in farm income has to be sharply accelerated. Therefore, strong measures will be needed to harness all possible sources of growth in farmers' income within as well as outside agriculture sector.

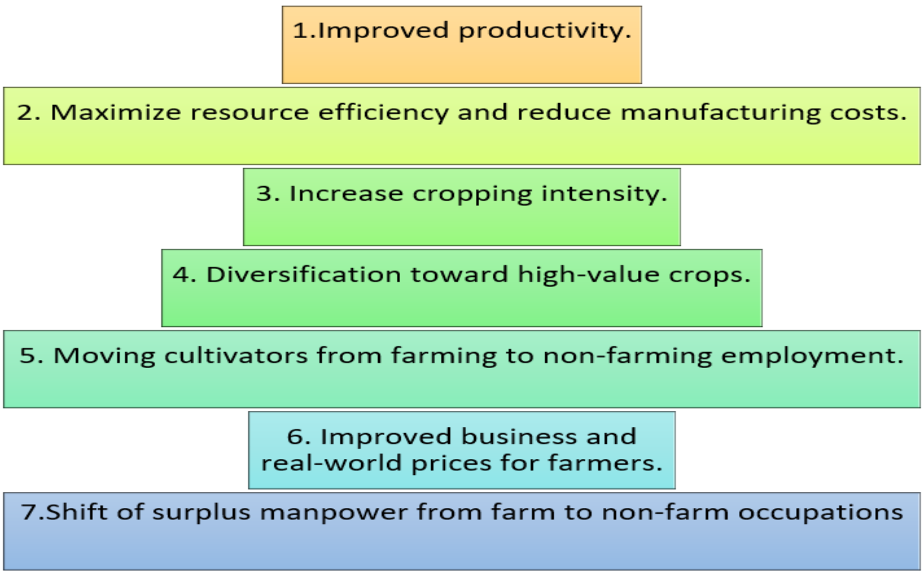

Figure 4 The Major Sources of Growth in Income action plan

Innovative agricultural approaches

Advanced farming methods:

Urban and semi-urban agriculture has lately gained popularity due to its sustainability, since it employs urban garbage, reusable natural resources, and waste to produce, process, and market agricultural products. (Antonio 2017; Ebel 2020). Some of the types of urban and peri-urban agriculture include allotment gardens (medium size vegetable garden in the municipal area), vertical farming (vertically inclined planes, vertically piled stratums, and another plant-growing substrate integrated), fertigation, aeroponic, and aquaponic (Jain and Janakiram 2016), a community garden (single or combination of multiple small pieces that has been planted), educational gardens (development of urban agriculture in an educational setting). Organic farming is another crop production method that has grown in popularity due to its significant economic creation and environmental benefits (IFOAM 2009). It is regarded as an environmentally benign strategy since it supplies carbon and other essential elements in the soil (Srivastava et al. 2018).

Smart agriculture:

The smart farming system is in high demand due to decreased soil productivity, increased climate change, and negative environmental consequences and propose integrating new technology, such as the Internet of Things (IoT) and linked devices, with the current food production system. and serve as a means of applying capital-intensive and high-tech modern Information and Communication Technologies (ICTs) such as artificial intelligence (AI), machine big data analysis, learning, and so on, in both on- and off-field settings. For example, high precision sensitive gears known as sensors, which can detect minute changes in light, moisture, and temperature, have found application in a variety of agricultural activities such as weather monitoring, information systems and precision agriculture, IT-based post-harvest produce handling, and so on. Other AI-based applications include smart harvesting, smart irrigation, smart greenhouses, quality-controlled processing, automated grading, price forecasting, etc.(Balkrishna et al. 2020; Gill and Sharma 2021).

Climate-smart agriculture:

Extreme changes in global climate circumstances have increased the food and nutrition crises significantly (World Bank, 2019b). Climate smart agriculture (CSA) is an integrated advanced agriculture concept that addresses agricultural issues caused by climate change (FAO 2010, Olorunfemi et al. 2019). In socio-agricultural settings, adaptation and mitigation are crucial words for managing climate change (CIFOR 2011, FAO 2012a).

Farmers income in base and target year (Rs.) India

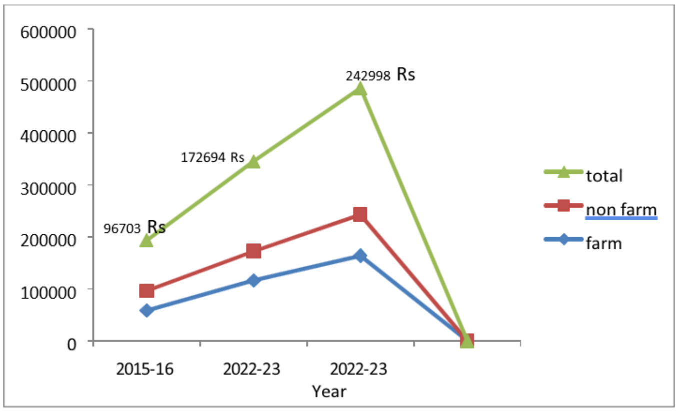

Figure 5 Farmers Income in Base and Target year (Rs.) India

Present gaps and interventions

After independence, India's agricultural reforms began with the green revolution, followed by the Agricultural Produce and Livestock Marketing (APLM) Act, Agricultural Produce and Livestock Contract Farming and Services Act, and initiatives like e-NAM and PM-AASHA. In response to the disruptions created by the Covid-19 lockout and contemporary issues, the government drafted three farm bill ordinances, which were later voted into law in 2020, with the goal of institutionalizing agricultural reform through legislation. These laws include the Farmers Produce Trade and Commerce (Promotion and Facilitation) Act 2020, the Farmers (Empowerment and Protection) Agreement in Price Assurance and Farm Services Act 2020, and the Essential Commodities (Amendment) Act 2020. (Ashrit 2021).

Future's perspective

Achieving the aim of doubling farmers' income needs a multifaceted approach:

- **Technological innovation:** Advances in agricultural technology, such as precision farming and artificial intelligence, can increase production and reduce expenses.
- **Market access and value addition:** Strengthening market ties and adding value to produce will assure fair pricing and decrease losses.
- **Sustainable practices:** Using eco-friendly practices such as organic farming increases long-term profitability while also protecting the environment.
- **Financial inclusion:** Access to finance, insurance, and digital banking services enables farmers to invest and manage risks efficiently.
- Training programs in new methods and entrepreneurship prepare farmers for success.

Policy support: Enabling policies for land, infrastructure, and research promote agricultural growth.

- **Social empowerment:** Providing resources and services to underprivileged farmers offers equal opportunity for all.
- **Global trade:** Exploring overseas markets broadens income streams and increases revenue possibilities. By mobilizing stakeholders and adopting these methods, farmers throughout the world may have a more successful and sustainable future.

Conclusion

In India, farmers form a major proportion of both producers as well as consumers. Thus, improving crop production and productivity, along with efficient and profitable farming, as a part of a pioneering growth strategy, can contribute significantly towards reducing hunger and poverty. Various countries have already set an example of agricultural development through small farmers and have shown that agricultural development is twice as effective in rural income generation as the development from other sectors. And using agriculture for economic development, especially in agriculture-based countries like India, requires continuous evaluation of smallholder farming practices to increase agricultural productivity. Agricultural productivity can be increased with science and technology interventions, government policies of extension services and institution-led reforms. Simultaneously, there should be a defined path and a time frame to work on such interventions and achieve a set goal within the time frame. As per the vision of the government, the target of doubling the income of farmers by 2022 is not an easy yet very laudable goal. But, relentlessly working on gaps and loopholes with concerted efforts, as per the action plan suggested in mission mode, with special emphasis on the welfare of our farmers, can bring about the necessary changes for overall agricultural development for national economic development with a special emphasis on the welfare of our farmers, who are solely responsible for fulfilling our needs for desired foods.

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ISSN : 2583-0910
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Peer reviewed
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Article ID : 04/XII/37/1224

PRESERVING BEAUTY: EXPLORING THE DETERMINANTS AND INTERVENTIONS FOR PROLONGING VASE LIFE OF CUT FLOWERS

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Abstract
The vase life of cut flowers is crucial for their marketability and customer satisfaction, making its enhancement a key focus in the floriculture industry. This article examines factors influencing vase life, with emphasis on preharvest and postharvest conditions. Preharvest factors such as light intensity, temperature, water, and nutrient management affect carbohydrate accumulation, directly impacting postharvest longevity. Postharvest factors, including temperature control, water relations, ethylene management, and microbial contamination, significantly influence flower quality. Vase solutions, enriched with carbohydrates, ethylene inhibitors, and antimicrobial agents, help extend vase life by promoting flower development and delaying senescence. Additionally, the use of sustainable alternatives, like natural extracts, offers an eco-friendly approach to improving vase life without relying on synthetic chemicals. Understanding these factors provides actionable insights to enhance the postharvest quality, longevity, and commercial value of cut flowers, ensuring a better experience for consumers and greater profitability in the floriculture market.

Keywords: Vase life, cut flowers, ethylene, postharvest, senescence

Introduction

The rise in global trade is driven by factors such as increased demand for flowers in celebrations, the growing popularity of floral arrangements in retail and events, and improvements in transportation that allow for the longer shelf-life of perishable flowers. The vase life quality of cut flowers is critical for ensuring customer satisfaction and encouraging reprise purchases. Flowers grown for the ornamental market must meet high-quality standards, which enhance their postharvest longevity, marketability, and commercial value. Like other plant organs, cut flowers are metabolically active and deteriorate over time. So, maintaining the freshness is a challenge in floriculture industry.

Another important thing plays a major role to extend the vase life of cut flowers is, handling techniques and it must balance two objectives: promoting bud growth and full bloom while slowing metabolic processes that lead to senescence. Research suggests that the appropriate composition of vase solutions can reduce respiration rates, delay senescence, and prolong flower longevity (Kazemi et al. 2011). Vase solutions often contain carbohydrates (e.g., sugars), ethylene biosynthesis inhibitors (e.g., silver thiosulphate, amino-ethoxy vinyl glycine), and germicides (e.g., 1-methylcyclopropene, chlorine dioxide, 8-hydroxyquinoline sulfate) to maximize the vase life of cut flowers. Use of many natural products such as essential oils, lemon juice, apple and fruit extracts are to find suitable alternatives to synthetic chemical vase solutions that are equally efficacious and environmentally friendly.

From harvest to consumer there are many barriers a flower is exposed to such factors should be taken care of to bring a fresh product. There are mainly four primary factors influencing vase life during crop production and postharvest stages are water relations, carbohydrate availability, ethylene sensitivity, and pathogens.

Factors Affecting Vase Life

The vase life of cut flowers refers to the duration for which they maintain an attractive appearance in a vase. Floral attributes influencing vase life include diameter of the floret and length of the floret, flower opening, changes in fresh weight of flower, stem diameter, senescence patterns, petal color/flower color, longevity of flower, and integrity of foliage. Both preharvest and postharvest factors significantly impact vase life.

The vase life of cut flowers is influenced by a range of preharvest and postharvest factors, as outlined below:

Preharvest Factors

Pre-harvest environmental factors, such as light, nutritional media, temperature, and water availability, influence carbohydrate accumulation and, consequently, the vase life of cut flowers. Preharvest conditions significantly affect the carbohydrate reserves in flowers, which are vital for maintaining postharvest longevity.

- **Light Intensity**: Adequate light exposure enhances carbohydrate synthesis through photosynthesis, directly impacting the vase life of flowers. Studies have shown that elevated light intensity and supplemental CO_2 increase vase life in species like carnations (*Dianthus caryophyllus*), chrysanthemums (*Dendranthema grandiflora*), and roses (*Rosa spp.*) by improving stomatal density and photosynthetic efficiency (Naing et al. 2016).
- **Temperature**: Optimal temperature during flower development is critical. High temperatures accelerate respiration, depleting carbohydrate reserves and reducing flower quality, while excessively low temperatures (below 15°C) can impair pigment synthesis and induce undesirable color changes (Rani and Singh 2014).
- **Water and Nutrient Management**: Proper hydration and balanced nutrition are essential for robust flower development. Conversely, high salinity in the growing medium can hinder water uptake, causing osmotic stress and adversely affecting vase life.

Postharvest Factors

Postharvest physiology involves maintaining functional processes in flowers after harvest. Controlled and modified atmosphere packaging (CAP/MAP) can regulate oxygen and carbon dioxide levels, reducing respiration and ethylene production, thereby extending vase life (Farber et al. 2003). Postharvest physiology encompasses the changes that occur in flowers from harvest to senescence.

- **Water Relations**: Water stress, caused by xylem blockage due to air emboli, microbial growth, or the accumulation of gums, is a leading cause of reduced vase life. Treatments like re-cutting stems underwater, using low-pH vase solutions, and adding biocides can improve water uptake and maintain turgidity.
- **Temperature Management**: Cooling flowers immediately after harvest reduces respiration rates, enzymatic activity, and ethylene production, thereby slowing senescence. Controlled

atmosphere (CAP) and modified atmosphere packaging (MAP) techniques can further optimize storage conditions by regulating oxygen, carbon dioxide, and humidity levels (Reid and Jiang 2012).

- **Ethylene Management**: Ethylene, a plant hormone, plays a pivotal role in flower senescence, particularly in ethylene-sensitive species like carnations. Inhibition of ethylene biosynthesis or action, using compounds like 1-MCP, STS, and amino-ethoxy vinyl glycine, effectively delays senescence and extends vase life.
- **Carbohydrate Supply**: The addition of sucrose to vase solutions compensates for the loss of natural carbohydrate supply post-harvest, promoting flower opening and delaying senescence. Other sugars and sugar alcohols, such as raffinose, trehalose, and mannitol, also act as osmo-protectants and extend vase life by mitigating stress.

Microbial Management

The vase solution is prone to microbial contamination, which can clog xylem vessels, leading to reduced water uptake and premature wilting. Antimicrobial agents like chlorine dioxide and 8-hydroxyquinoline sulfate are commonly added to vase solutions to inhibit microbial growth and maintain water quality.

Biochemical and Metabolic Changes: Cut flowers undergo several physiological changes postharvest, including:

- **Wounding and Emboli Formation**: Cutting stems introduces air emboli, which obstruct water flow in the xylem. Techniques such as deep-water immersion and biocide treatments can alleviate these blockages (Ratnayake et al. 2010).
- **Respiration and Senescence**: Increased respiration and cellular degradation are hallmarks of senescence. Ethylene accelerates these processes by inducing protease and ACC oxidase activity, leading to petal wilting and abscission (Da Silva 2003).
- **Color Changes**: Aging flowers often exhibit color shifts due to changes in pigment composition and pH. For instance, anthocyanins transition from red to blue as cellular pH increases during senescence.

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